



Total Maximum Daily Load

for

**Grand River, Middle Fork Grand River, East Fork
Grand River, Locust Creek, East Fork Locust Creek**

**Worth, Gentry, DeKalb, Clinton, Harrison, Daviess, Caldwell, Ray,
Mercer, Grundy, Livingston, Carroll, Putnam, Sullivan, Linn,
Chariton, Nodaway, and Andrew Counties**

303(d) Listing: *Escherichia coli* Bacteria

**Submitted: October 15, 2024
Approved: December 16, 2024**

WATER BODY SUMMARY
Total Maximum Daily Loads (TMDL) for Grand River Watershed
303(d) Listing: *Escherichia coli* (*E. coli*) Bacteria

Names: Grand River, Middle Fork Grand River, East Fork Grand River
Locust Creek, East Fork Locust Creek

Location: Worth, Gentry, DeKalb, Clinton, Harrison, Daviess, Caldwell, Ray, Mercer, Grundy, Livingston, Carroll, Putnam, Sullivan, Linn, Nodaway, Andrew, and Chariton counties

TMDL Development Priority: High

8-digit Hydrologic Unit Codes (HUC):¹

- 10280101 – Upper Grand
- 10280102 – Thompson River
- 10280103 – Lower Grand

Water Body Identification (WBID) and Hydrologic Class:²

- Grand River WBID (593), Class P
- Middle Fork Grand River (468), Class P
- East Fork Grand River (457), Class P
- Locust Creek (606), Class P
- East Fork Locust Creek (608 and 610), Class P and Class C



Location of watershed in Missouri

Designated Uses:³

- Irrigation
- Livestock and wildlife protection
- Human health protection
- Warm water habitat (aquatic life)
- Whole body contact recreation category A (WBIDs 457, 593, 468, and 610)
- Whole body contact recreation category B (WBIDs 606 and 608)
- Secondary contact recreation
- Drinking water supply (WBIDs 457, 593, and 606)

Impaired Use:

- Whole body contact recreation category A (WBIDs 457, 593, 468 and 610)
- Whole body contact recreation category B (WBIDs 606 and 608)
- Secondary contact recreation (WBID 608)

¹ Watersheds are delineated by the U.S. Geological Survey using a nationwide system based on surface hydrologic features. This system divides the country into 2,270 8-digit hydrologic units (USGS 2019). A hydrologic unit is a drainage area delineated to nest in a multilevel, hierarchical drainage system. A hydrologic unit code is the numerical identifier of a specific hydrologic unit consisting of a 2-digit sequence for each specific level within the delineation hierarchy (FGDC 2003).

² For hydrologic classes see 10 CSR 20-7.031(1)(E). Class P streams maintain permanent flow even in drought periods. Class C streams may cease flow in dry periods but maintain permanent pools which support aquatic life.

³ For designated uses see 10 CSR 20-7.031(1)(F) and 10 CSR 20-7.031 Table H. Presumed uses are assigned per 10 CSR 20-7.031(2)(A) and (B) and are reflected in the Missouri Use Designation Dataset described at 10 CSR 20-7.031(2)(F).

Pollutant Identified on the 2022 303(d) List:
Escherichia coli (*E. coli*) (fecal indicator bacteria)

Identified Sources on the 2022 303(d) List:
Rural nonpoint sources (All WBIDs)
Milan Lagoon (WBID 608)

Length and Location of Impaired Segments:

Grand River (593): 56.0 miles, Mouth to Shoal Creek

Middle Fork Grand River (468): 27.5 miles, Mouth to Section 12, Township 66N, Range 31W

East Fork Grand River (457): 28.7 miles, Mouth to Section 29, Township 66N, Range 30W

Locust Creek (606): 91.7 miles, Mouth to State Line

East Fork Locust Creek (608): 16.7 miles, Mouth to Section 2, Township 62N, Range 20W

East Fork Locust Creek (610): 15.7 miles, Section 2, Township 62N, Range 20W to Section 12,
Township 64N, Range 20W

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1. Introduction

In accordance with Section 303(d) of the federal Clean Water Act, the Missouri Department of Natural Resources is establishing this total maximum daily load (TMDL) to address elevated concentrations of *Escherichia coli* (*E. coli*) bacteria in six water quality limited stream segments in the Grand River watershed in north central Missouri.⁴ These six streams are included on Missouri's 2022 303(d) List of Impaired Waters due to exceedances of Missouri's *E. coli* bacteria criteria. These listings were approved by the U.S. Environmental Protection Agency (EPA) on August 2, 2023.⁵

Section 303(d) of the federal Clean Water Act and Title 40 of the Code of Federal Regulations (CFR) Part 130 require states to develop TMDLs for waters that do not meet applicable water quality standards. Missouri's Water Quality Standards at Title 10 of the Code of State Regulations (CSR) Division 20 Chapter 7, Rule 7.031 consist of three major components: designated uses, water quality criteria to protect those uses, and an antidegradation policy. A TMDL is equal to the loading capacity of a water body for a specific pollutant and represents the maximum amount of a pollutant that a water body can assimilate and still attain and maintain water quality standards. The *E. coli* bacteria loading capacity for an impaired stream is derived from the maximum *E. coli* concentration allowed by Missouri's Water Quality Standards and is translated to mass loads using stream flow under all recorded conditions. Once the loading capacity of a water body has been quantified, existing and future point sources and nonpoint sources are assessed for their potential to contribute the pollutants of concern. In accordance with 40 CFR 130.2, contributing point sources are assigned a portion of the available loading capacity as a wasteload allocation and nonpoint sources are assigned a load allocation. In accordance with federal Clean Water Act section 303(d)(1)(C), a margin of safety is also included. Margins of safety can be explicit (numeric) or implicit (qualitative) to account for any lack of knowledge concerning the relationship between pollutant loading and water quality, uncertainty associated with the model assumptions, or data inadequacies (40 CFR 130.7). The TMDL for any given pollutant is the sum of the wasteload allocation, the load allocation, and the margin of safety.

2. Watershed Description

Grand River watershed is located in north central Missouri and south central Iowa (Figure 1). The Grand River (WBID 593) is formed by the Upper Grand River and Shoal Creek (WBID 518) merging together approximately 3 miles south of Chillicothe. The watershed is composed of three 8-digit hydrologic unit code (HUC) subbasins: the Upper Grand subbasin, the Lower Grand subbasin, and the Thompson subbasin. The Upper Grand subbasin is 3,325.95 square miles and is cataloged by the U.S. Geological Survey (USGS) as HUC 10280101. The Lower Grand subbasin is 2,360.80 square miles and its 8-digit HUC is 10280103. The Thompson subbasin is 2,201.13 square miles and its 8-digit HUC is 10280102. The total watershed area draining to Grand River is approximately 7,900 square miles.

⁴ A water quality limited segment is any segment where it is known that water quality does not meet applicable water quality standards, or is not expected to meet applicable water quality standards, even after the application of the technology-based effluent limitations required by sections 301(b) and 306 of the federal Clean Water Act (40 CFR 130.2).

⁵ The department maintains current and past 303(d) lists and corresponding assessment worksheets online at: dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/impaired-waters.

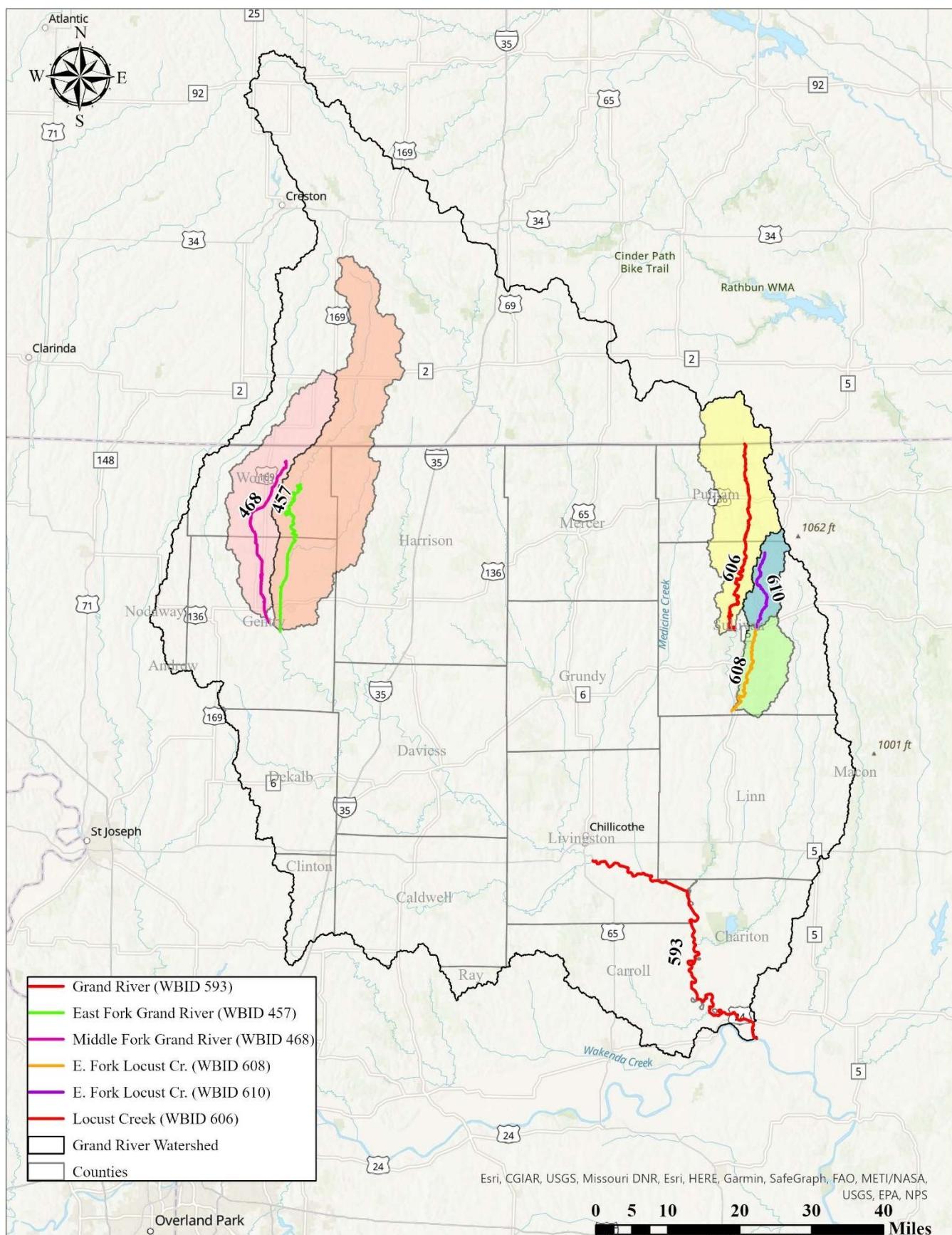


Figure 1. Location of impaired streams segments in the Grand River watershed

2.1 Geology, Physiography, and Soils

The Grand River watershed is located within the Central Plains/Grand/Chariton ecological drainage unit, which primarily consists of north central Missouri and south central Iowa (MoRAP 2005). Ecological drainage units are groups of watersheds that have similar biota, geography, and climate characteristics (USGS 2009).

The Grand River watershed is also located in the Loess Flats and Till Plains EPA Level IV ecoregion. Ecoregions are areas with similar ecosystems and environmental resources and are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. By recognizing spatial differences in ecosystems, ecoregions stratify the environment by its probable response to disturbance (Chapman et al. 2002). Ecoregions are defined in Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(H). This ecoregion is named after its strongest feature, the thick loess deposits. Below the loess deposits are Pennsylvanian shales, limestones, and sandstone. This area is generally flat with an average gradient of 7.9 meters per kilometer (m/km). There are few springs in this ecoregion and streams here are usually surface water dominated (MoRAP 2005).

Soils in the watershed are categorized into hydrologic soil groups based on similar runoff potentials. Each hydrologic soil group indicates the rate at which water enters the soil profile under conditions of a bare, thoroughly wetted soil surface (NRCS 2009). This infiltration rate determines the quantity of precipitation that flows over land to water bodies as direct runoff. Group A soils have the highest rate of infiltration and the lowest runoff potential. Group D soils have the lowest rate of infiltration and highest runoff potential. Many wet soils fall into dual soil groups (e.g., Group C/D) due to the presence of a seasonal high water table that results in saturation to the soil surface. Dual hydrologic soil groups account for this condition by providing both the drained and undrained condition of the soil.⁶ It should be noted that soil runoff potential is only one factor that determines the volume of runoff in a watershed. Impervious surfaces, vegetative cover, slope, rainfall intensity, and land use can significantly influence the potential for runoff regardless of the characteristics of the underlying soil. Figure 2 shows the distribution of hydrologic soil groups in the Missouri portion of the Grand River watershed, as well as known springs, and gaining streams. Table 1 provides a summary of the hydrologic soil groups in the Missouri portions of the impaired segment watersheds by area.

⁶ For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at least 24 inches (60 centimeters) below the surface in a soil where it would be higher in a natural state (NRCS 2009).

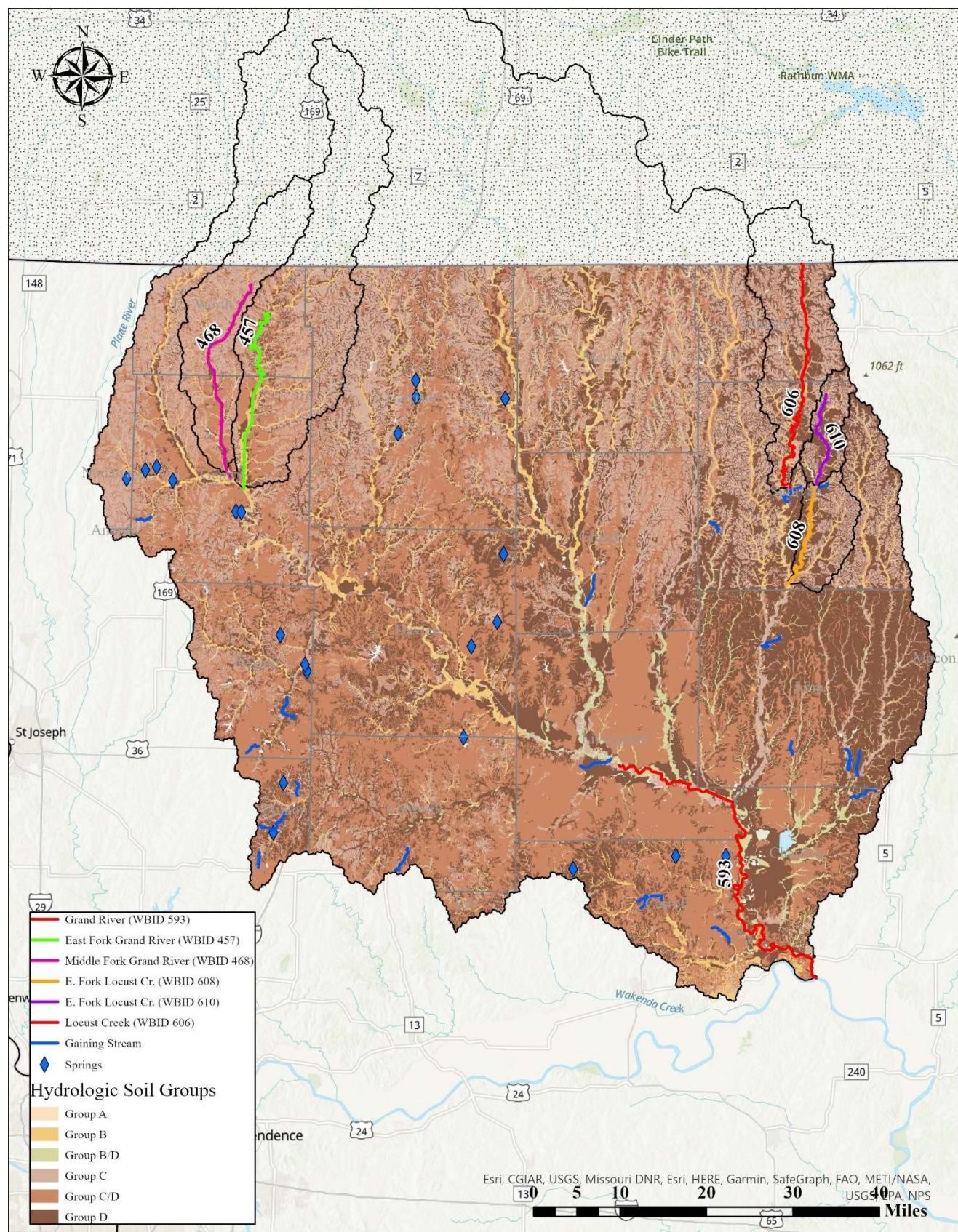


Figure 2. Hydrologic soil groups in the Grand River watershed in Missouri

Table 1. Hydrologic soil groups in the Grand River watershed in Missouri (NRCS 2023)

Hydrologic Soil Group	Area in the Watershed	
	Grand River (WBID 593)	
	Square miles	Percent
Group A	0.91	0.01%
Group B	346.11	5.47%
Group B/D	137.02	2.16%
Group C	1,556.48	24.59%
Dual Group C/D	2,307.51	36.45%
Group D	1,981.94	31.31%
Total ⁷	6,329.96	100.00%
Hydrologic Soil Group	Area in the Watershed	
	Middle Fork Grand River (WBID 468)	
	Square miles	Percent
Group B	13.55	8.36%
Group B/D	0.01	0.01%
Group C	76.92	47.48%
Dual Group C/D	52.66	32.50%
Group D	18.88	11.66%
Total ⁷	162.02	100.00%
Hydrologic Soil Group	Area in the Watershed	
	East Fork Grand River (WBID 457)	
	Square miles	Percent
Group B	25.82	8.90%
Group B/D	0.03	0.01%
Group C	129.40	44.58%
Dual Group C/D	80.12	27.60%
Group D	54.89	18.91%
Total ⁷	290.26	100.00%
Hydrologic Soil Group	Area in the Watershed	
	Locust Creek (WBID 606)	
	Square miles	Percent
Group B	11.61	5.87%
Group B/D	1.12	0.57%
Group C	85.00	43.02%
Dual Group C/D	13.27	6.71%
Group D	86.59	43.82%
Total ⁷	197.58	100.00%
Hydrologic Soil Group	Area in the Watershed	
	East Fork Locust Creek (WBID 608,610)	

⁷ Total area values exclude open water and undefined areas within the watersheds, resulting in smaller than actual total watershed areas. Areas presented only represent lands within Missouri.

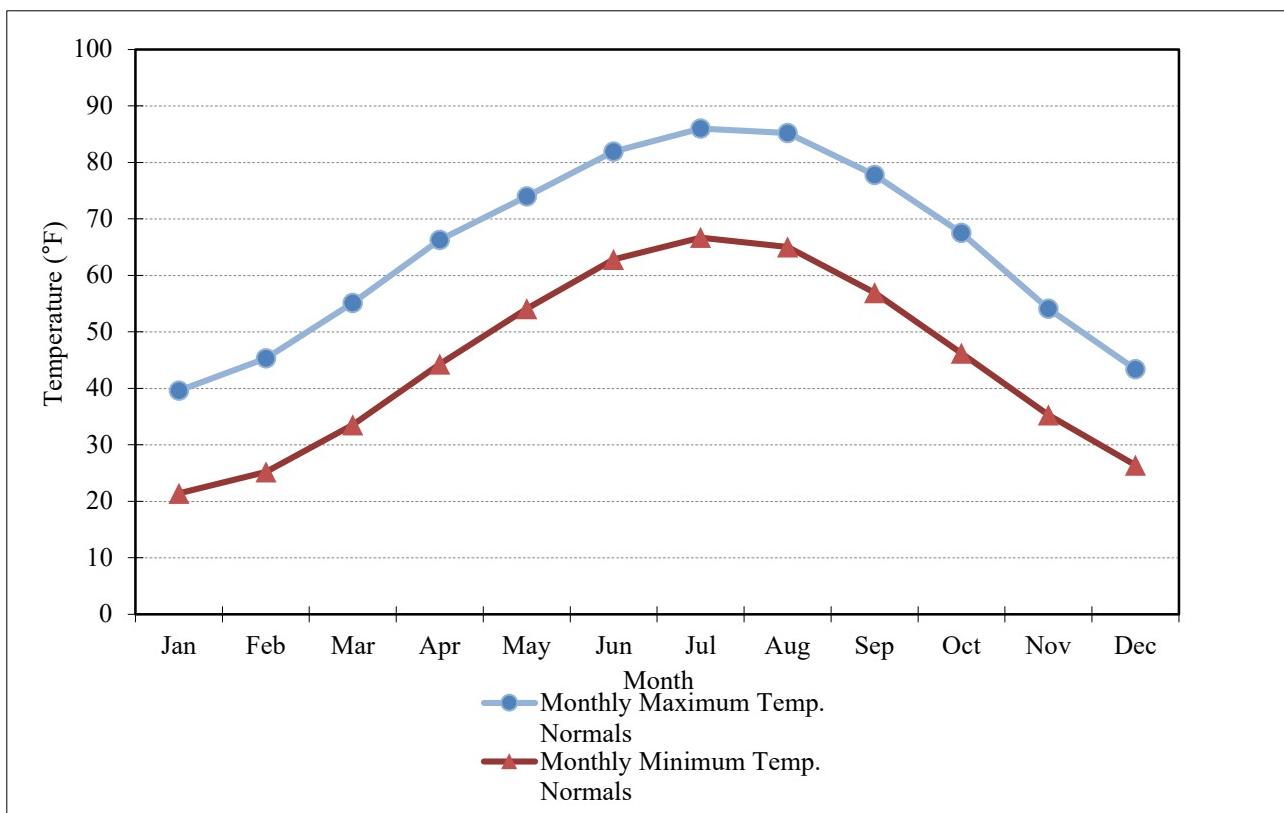
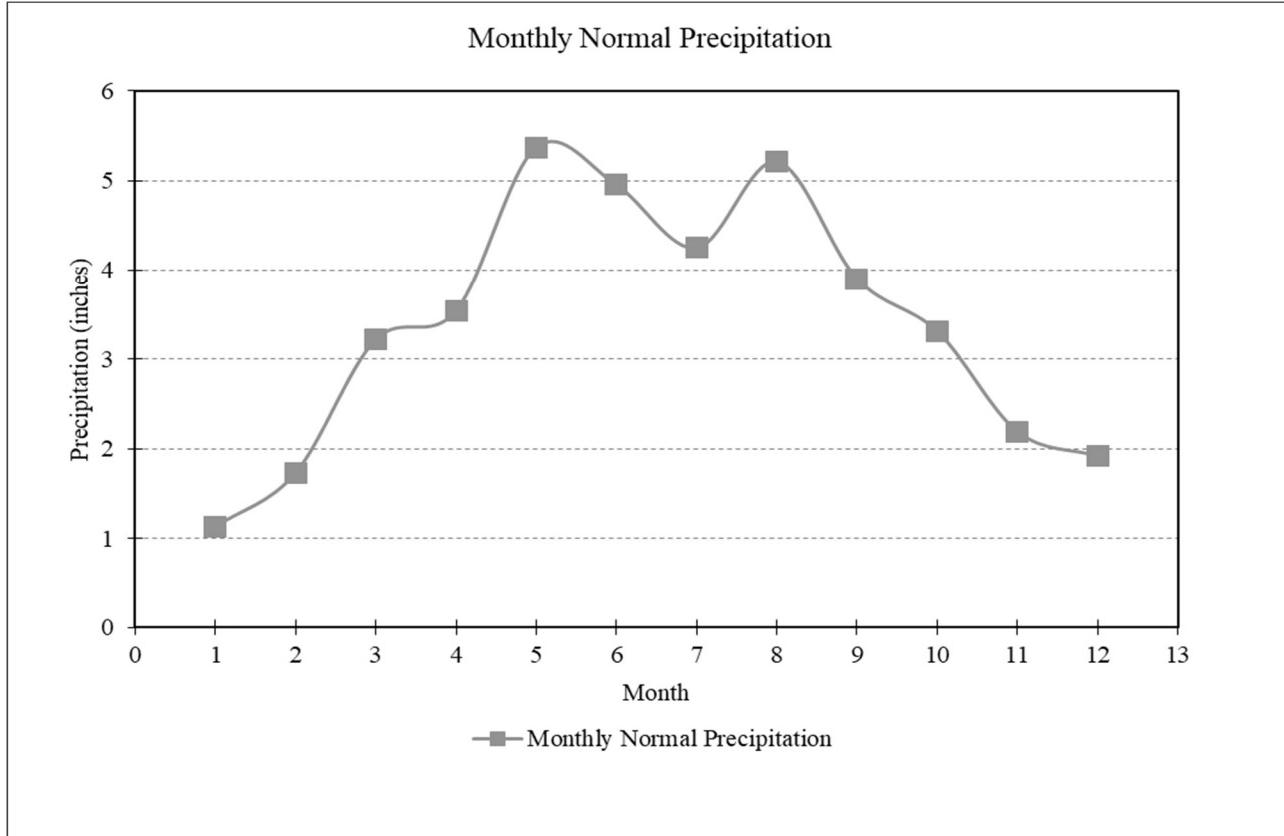
	Square miles	Percent
Group B	10.08	8.18%
Group B/D	0.72	0.59%
Group C	42.64	34.60%
Dual Group C/D	3.99	3.24%
Group D	65.79	53.39%
Total ⁷	123.23	100.00%

2.2 Climate

The most recent climate data from a weather station in close proximity to the Grand River watershed were measured at the National Centers for Environmental Information Chillicothe Weather Station (USC00231580) in Livingston County, Mo. The climate normals were developed based on temperature and precipitation data collected at that station between 1991 and 2020 (NOAA 2020). Precipitation normals are especially important because they relate to stream flow and runoff events that influence pollutant loading. Table 2 presents the 30-year monthly climate normals from the Chillicothe Weather Station for precipitation and temperature. Figures 3 and 4 further summarize these data.

Table 2. 30-year monthly climate normals at the Chillicothe weather station

Month	Precipitation Total	Minimum Temperature	Maximum Temperature
	inches	°F	°F
January	1.13	16.40	35.00
February	1.73	17.90	38.00
March	3.22	31.80	52.70
April	3.54	41.30	63.70
May	5.37	53.70	73.80
June	4.95	64.30	84.20
July	4.25	67.60	87.90
August	5.21	64.60	85.50
September	3.90	56.00	78.90
October	3.31	42.50	65.90
November	2.19	31.20	52.90
December	1.92	21.20	39.30
	Total	Average	Average
	40.72	42.38	63.15

**Figure 3.** Monthly temperature normals at the Chillicothe weather station**Figure 4.** Monthly precipitation normals at the Chillicothe weather station

2.3 Population

State and county population estimates are available from the U.S. Census Bureau's 2020 census and can be localized using census block data (U.S. Census Bureau 2020). Population estimates for the Grand River watershed were derived using geographic information system (GIS) software by overlaying the watershed boundary over a map of census blocks (Figure 5). Wherever the centroid of a census block fell within the watershed boundary, the entire population of the census block was included in the total. If the centroid of the census block was outside the boundary, the population of the entire block was excluded. The municipal population was estimated using a similar method whereby municipal areas were overlain on the map of census blocks. The rural population was calculated as the difference between the municipal population and the total population. The majority of the watershed's population resides in Missouri. As shown in Table 3, the population in the Grand River watershed decreased between the 2010 and 2020 census.

Table 3. Population estimates for the Grand River watershed

Missouri Population Data								
Municipal			Rural			Total		
2000	2010	2020	2000	2010	2020	2000	2010	2020
63,621	64,057	57,761	40,680	41,936	39,054	104,301	105,993	96,815
Iowa Population Data								
Municipal			Rural			Total		
2000	2010	2020	2000	2010	2020	2000	2010	2020
--	13,685	12,555	--	8,918	9,033	--	22,603	21,588
Grand River Watershed Total Population Data								
Municipal			Rural			Total		
2000	2010	2020	2000	2010	2020	2000	2010	2020
--	77,742	70,316	--	50,854	48,087	--	128,593	118,403

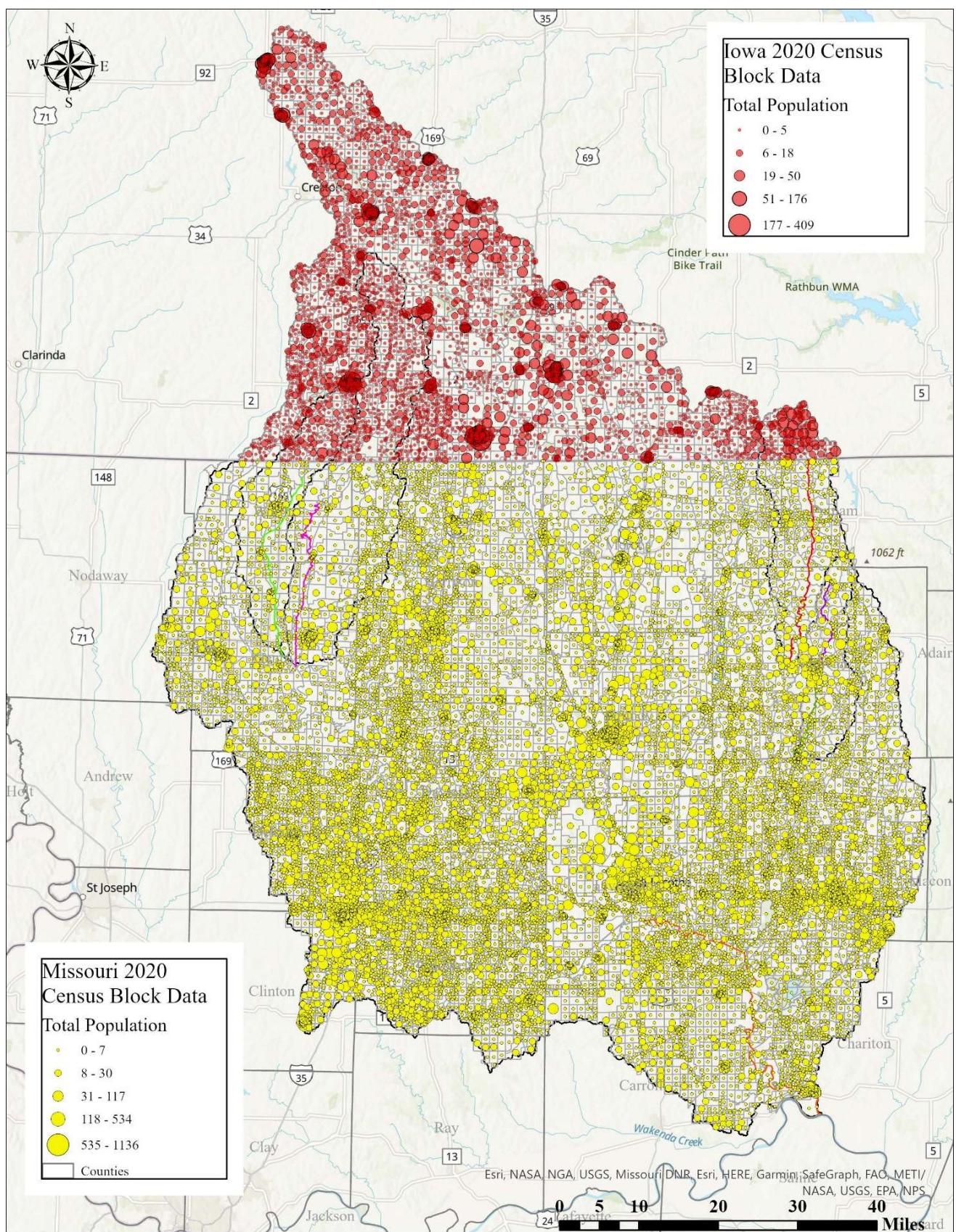
U.S. Census Bureau data can also assist with identifying areas in the watershed with potential environmental justice concerns. EPA defines environmental justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (USEPA 2014a). Communities having environmental justice concerns may qualify for financial and strategic assistance for addressing environmental and public health issues. One example of financial assistance the department offers that may be available to areas having environmental justice concerns is Section 319 grant funding to address nonpoint sources. The department evaluates 319 grants on a number of criteria, but gives higher priority for selection to proposed projects in disadvantaged communities. Additional grant and financial resource information is available on EPA's environmental justice website at www.epa.gov/environmentaljustice.

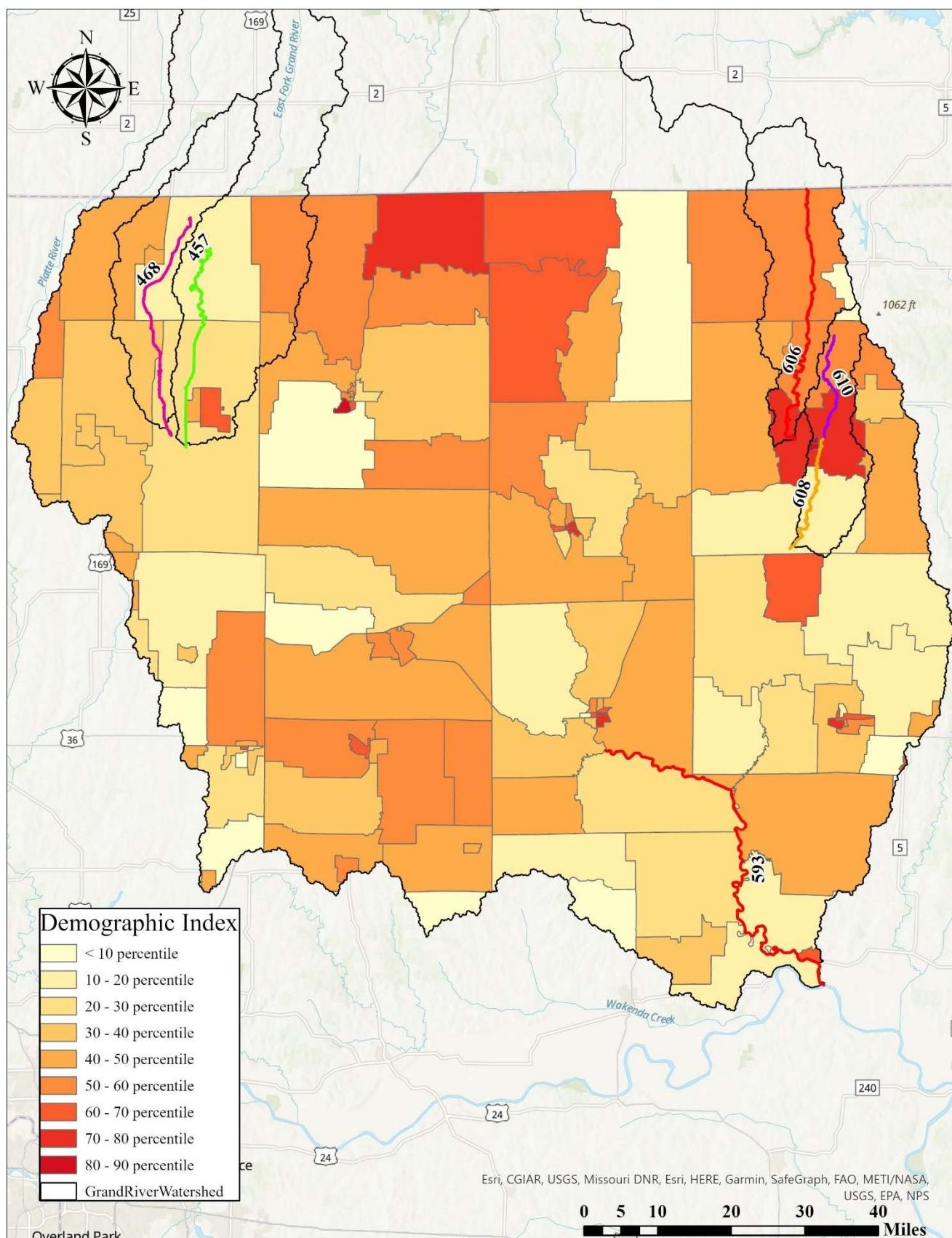
Figure 6 shows census block groups' demographic index. This information is just one approach to identify areas where potential environmental justice concerns may exist. The index is calculated by the following equation:

$$\text{Demographic index} = \frac{\% \text{ People of Color} + \% \text{ Low Income}}{2}$$

The demographic data used in this analysis is from the U.S. Census Bureau and is derived from the Demographic Index used in EPA's web-based EJSCREEN tool. The EJSCREEN tool is available at <https://www.epa.gov/ejscreen>. This index is displayed as the state's percentile to more easily compare areas across the state. Within the watershed, census blocks demographic index range from the first percentile to 83rd percentile. The block with the highest index is near Sullivan and is in the 83rd percentile meaning that its demographic index is 83 percent higher than other census blocks within the state of Missouri. Areas with an index above the 80th percentile may have environmental justice concerns.

Environmental justice encompasses a wide set of concerns and demographics. In addition to the Demographic Index, the EJSCREEN tool integrates 11 environmental pollution and 6 demographic indicators. Due to the numerous factors considered by the EJSCREEN tool, the department provides only generalized information in this TMDL. Local communities can identify and prioritize other environmental justice concerns for their watershed.

**Figure 5. 2020 population in the Grand River watershed**

**Figure 6. Demographic Index of the Grand River Watershed by Census Block Groups**

2.4 Land Cover

A land cover analysis was completed using the 2019 National Land Cover Database published by the U.S. Geological Survey (USGS) (Dewitz 2019). Land cover types present in the Grand River watershed are summarized in Table 4 for each impaired segment's subwatershed. Figure 7 depicts the distribution of the land cover types throughout the Grand River watershed. Figures 7 through 9 depict land cover types within the Grand River subwatersheds. Areas available for agricultural land uses (i.e., Hay and Pasture, and cultivated crops) cover the majority of the watersheds, while forested lands make up lower portions of land cover in the watershed. Developed areas account for less than 5 percent of the entire watershed area and each impaired stream's subwatershed in Missouri.

Table 4. Land cover in the Grand River watersheds

Grand River (WBID 593)				
Land Cover Type	Total Watershed		Missouri Only	
	Area (mi ²)	Percent	Area (mi ²)	Percent
Developed, High Intensity	3.89	0.05%	3.31	0.05%
Developed, Medium Intensity	137.40	1.74%	99.82	1.62%
Developed, Low Intensity	22.66	0.29%	17.82	0.29%
Developed, Open Space	189.56	2.40%	158.04	2.57%
Barren Land	6.64	0.08%	5.92	0.10%
Cultivated Crops	2,388.64	30.27%	1,120.39	18.20%
Hay and Pasture	3,442.56	43.63%	1,791.76	29.10%
Scrub and Herbaceous	1,361.71	17.26%	2,682.01	43.56%
Forest	45.59	0.58%	16.43	0.27%
Wetlands	224.98	2.85%	207.40	3.37%
Open Water	66.41	0.84%	53.56	0.87%
Totals	7,890.04	100.00%	6,156.44	100.00%
Middle Fork Grand River (WBID 468)				
Land Cover Type	Total Watershed		Missouri Only	
	Area (mi ²)	Percent	Area (mi ²)	Percent
Developed, High Intensity	0.11	0.06%	0.06	0.04%
Developed, Medium Intensity	0.63	0.32%	0.32	0.23%
Developed, Low Intensity	3.67	1.85%	2.03	1.46%
Developed, Open Space	5.48	2.77%	4.00	2.87%
Barren Land	0.02	0.01%	0.00	0.00%
Cultivated Crops	50.21	25.37%	31.78	22.78%
Hay and Pasture	104.26	52.69%	72.82	52.19%
Scrub and Herbaceous	29.57	14.94%	25.28	18.12%
Forest	1.13	0.57%	0.89	0.63%
Wetlands	1.72	0.87%	1.44	1.03%
Open Water	1.10	0.56%	0.91	0.65%
Totals	197.87	100.00%	139.53	100.00%
East Fork Grand River (WBID 457)				

Land Cover Type	Total Watershed		Missouri Only	
	Area (mi ²)	Percent	Area (mi ²)	Percent
Developed, High Intensity	0.13	0.03%	0.10	0.04%
Developed, Medium Intensity	0.74	0.17%	0.44	0.16%
Developed, Low Intensity	5.91	1.37%	2.82	1.06%
Developed, Open Space	10.44	2.41%	7.42	2.78%
Barren Land	0.16	0.04%	0.05	0.02%
Cultivated Crops	117.98	27.25%	60.09	22.54%
Hay and Pasture	207.92	48.02%	125.30	47.00%
Scrub and Herbaceous	78.55	18.14%	62.15	23.32%
Forest	2.80	0.65%	2.10	0.79%
Wetlands	6.01	1.39%	4.75	1.78%
Open Water	2.37	0.55%	1.36	0.51%
Totals	433.00	100.00%	266.58	100.00%
Locust Creek (WBID 606)				
Land Cover Type	Total Watershed		Missouri Only	
	Area (mi ²)	Percent	Area (mi ²)	Percent
Developed, High Intensity	0.04	0.02%	0.04	0.02%
Developed, Medium Intensity	0.22	0.10%	0.93	0.54%
Developed, Low Intensity	1.67	0.75%	0.14	0.08%
Developed, Open Space	5.94	2.66%	4.96	2.85%
Barren Land	0.06	0.03%	0.06	0.03%
Cultivated Crops	43.32	19.42%	23.19	13.33%
Hay and Pasture	112.00	50.22%	91.69	52.70%
Scrub and Herbaceous	51.99	23.31%	45.96	26.42%
Forest	1.91	0.85%	1.63	0.94%
Wetlands	4.72	2.12%	4.39	2.52%
Open Water	1.16	0.52%	1.02	0.58%
Totals	223.03	100.00%	174.00	100.00%
East Fork Locust Creek (WBID 608,610)				
Land Cover Type	Total Watershed			
	Area (mi ²)		Percent	
Developed, High Intensity	0.09		0.08%	
Developed, Medium Intensity	1.68		1.35%	
Developed, Low Intensity	0.32		0.26%	
Developed, Open Space	3.60		2.89%	
Barren Land	0.02		0.02%	
Cultivated Crops	8.22		6.61%	
Hay and Pasture	68.60		55.20%	
Scrub and Herbaceous	36.98		29.75%	
Forest	1.22		0.98%	

Wetlands	2.11	1.70%
Open Water	1.45	1.17%
Totals	124.29	100.00%

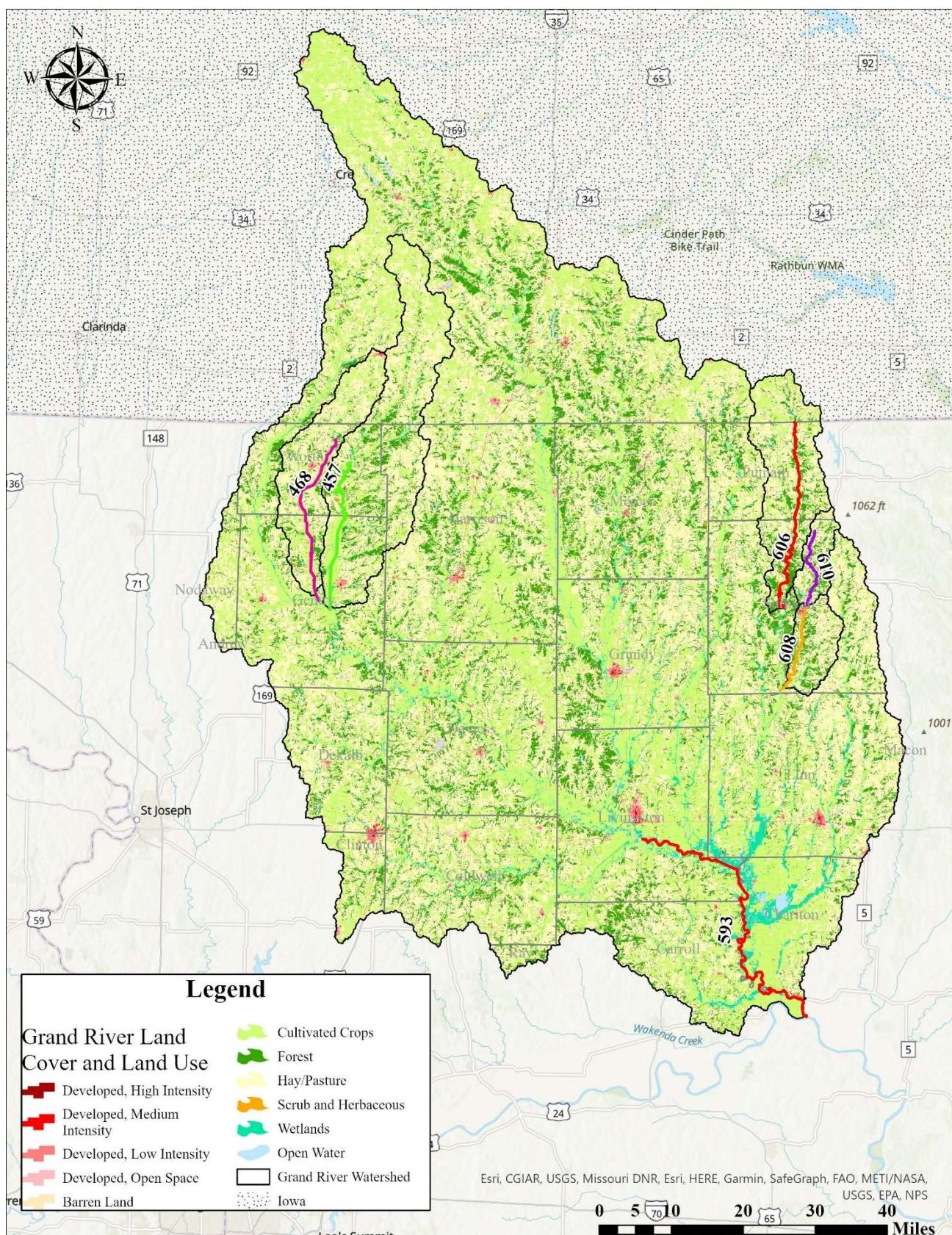


Figure 7. Land cover in the Grand River watershed

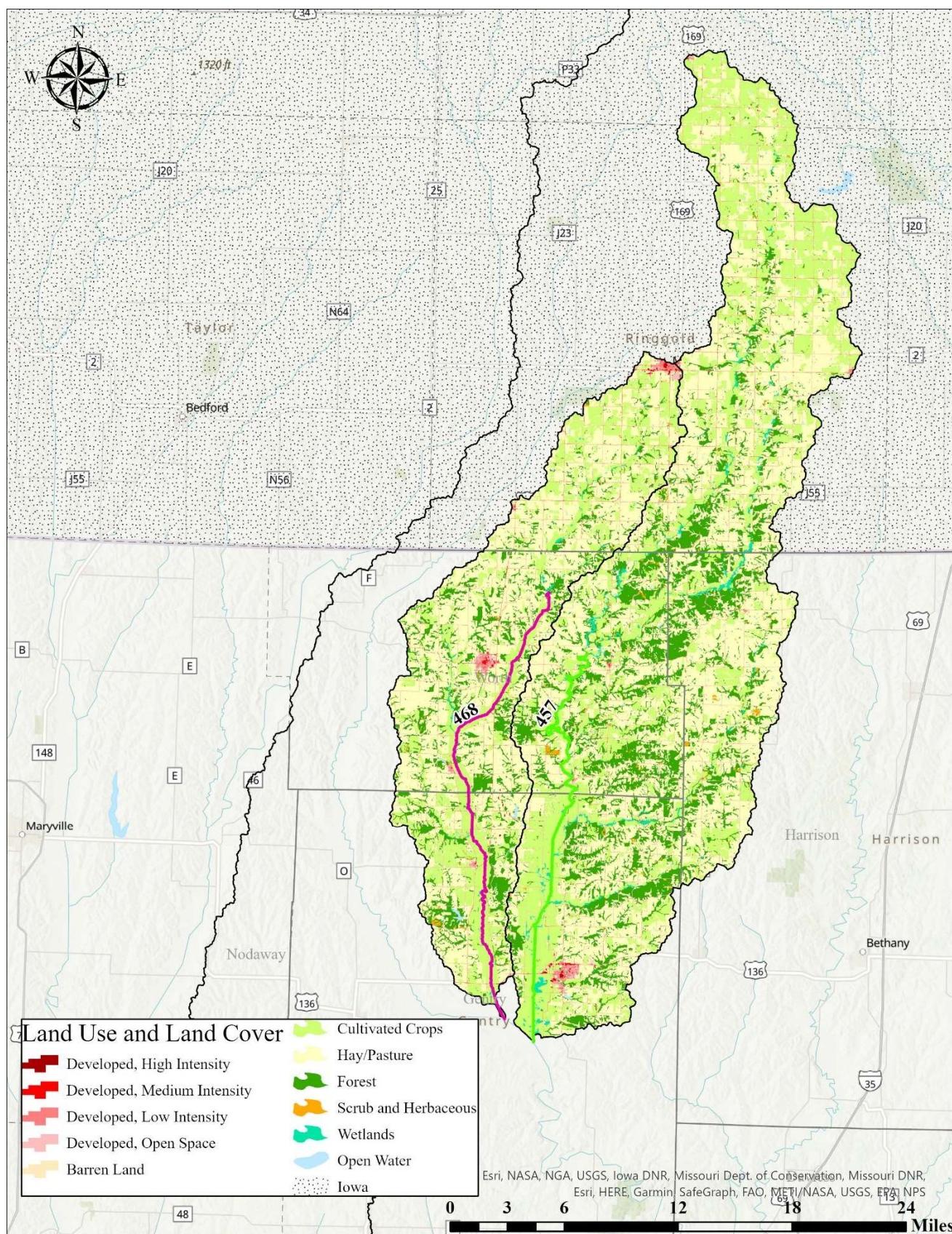


Figure 8. Land cover in the Middle Fork Grand River and East Fork Grand River watersheds

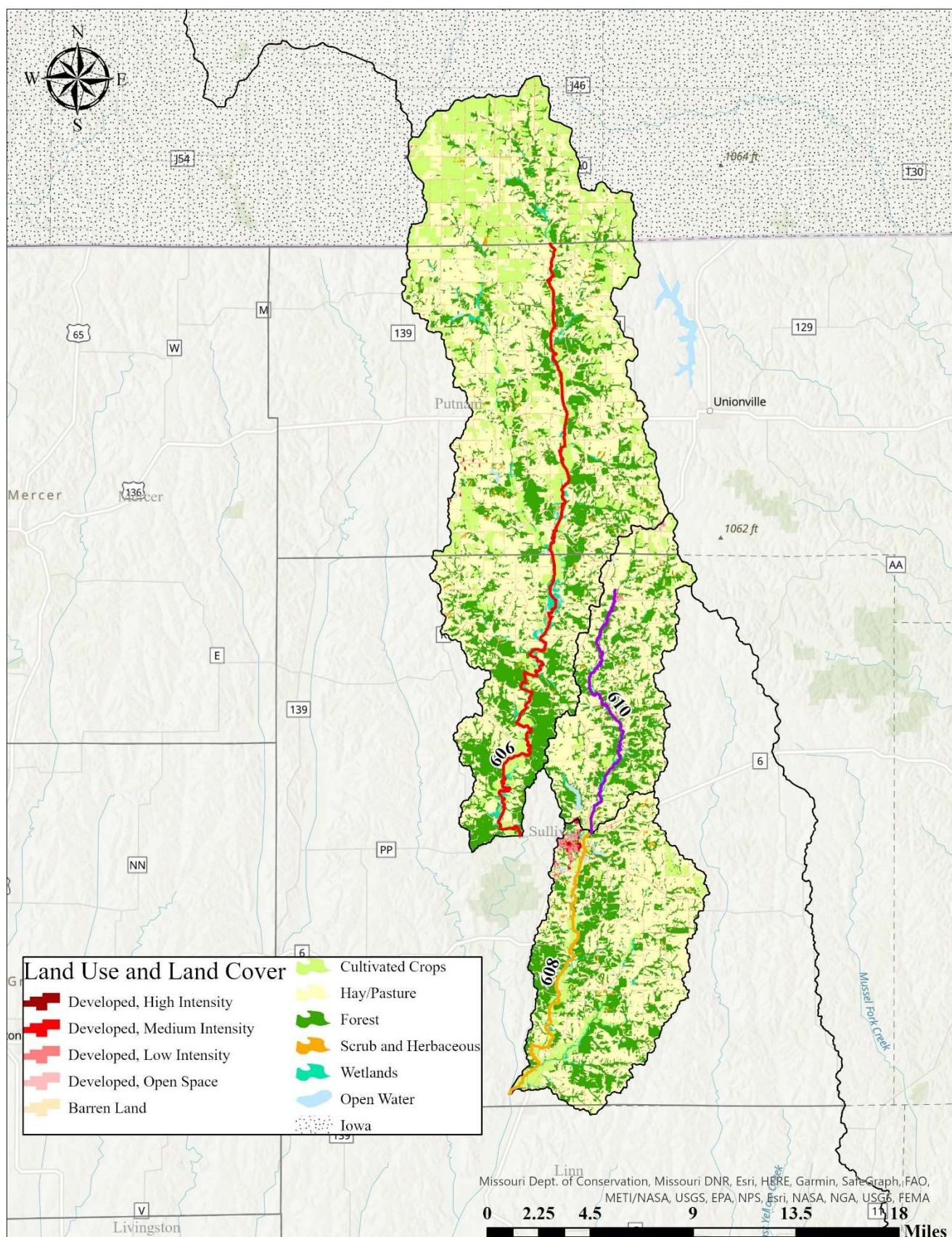


Figure 9. Land cover in the Locust Creek and East Fork Locust Creek watersheds

3. Applicable Water Quality Standards

TMDLs identify the maximum pollutant load that a water body can assimilate and still attain and maintain water quality standards. Water quality standards are therefore central to the TMDL development process. Under the federal Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters (U.S. Code Title 33, Chapter 26, Subchapter III). Water quality standards consist of three major components: designated uses, water quality criteria, and an antidegradation policy. In accordance with federal regulations at 40 CFR 131.10, Missouri's Water Quality Standards for each individual water body also provide for the attainment and maintenance of water quality in any downstream waters. Revising existing water quality standards is not within the purview of TMDL development. If future water quality monitoring demonstrates that existing water quality standards are not protective of individual water bodies or downstream uses, new water quality standards can be proposed in accordance with the guidance provided in EPA's Water Quality Standards Handbook.⁸

3.1 Designated Uses

Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(C) defines designated uses that are assigned to individual water bodies in accordance with 10 CSR 20-7.031(2) and are listed in 10 CSR 20-7.031, Table G (Lakes) and Table H (Streams). Missouri's Water Quality Standards designate the following uses of Grand River watershed:

- Irrigation
- Livestock and wildlife protection
- Human health protection
- Warm water habitat (aquatic life)
- Whole body contact recreation category A (WBIDs 457, 593, 468, and 610)
- Whole body contact recreation category B (WBIDs 606 and 608)
- Secondary contact recreation
- Drinking water supply (WBIDs 457, 593, and 606)

For the streams addressed by this TMDL, the whole body contact recreational designated uses are impaired due to high *E. coli* bacteria concentrations. Additionally, for East Fork Locust Creek (WBID 608) the secondary contact recreational use is also impaired due to high concentrations of *E. coli*. Whole body contact recreation includes activities that involve direct human contact with waters of the state to the point of complete body submergence (10 CFR 20-7.031(1)(C)2.A.). During whole body contact activities, such as swimming, accidental ingestion of the water may occur and there is direct contact to sensitive body organs, such as the eyes, ears, and nose. Whole body contact recreation category A applies to waters that have been established by the property owner as public swimming areas and waters with documented existing whole body contact recreation uses by the public (10 CSR 20-7.031(1)(C)2.A.(I)). Whole body contact recreation category B applies to waters designated for whole body contact recreation not contained within category A (10 CSR 20-7.031(1)(C)2.A.(II)). Secondary contact recreation, which includes activities such as boating, fishing, and wading, are activities that may result in contact with the water that is either incidental or accidental and the probability of ingesting appreciable quantities of water is minimal (10 CSR 20-7.031(1)(C)2.B.).

⁸ <https://www.epa.gov/wqs-tech/water-quality-standards-handbook>

3.2 Water Quality Criteria

Water quality criteria represent a level of water quality that supports and protects particular designated uses. Water quality criteria are expressed as specific numeric criteria and as general narrative statements. Missouri's Water Quality Standards (10 CSR 20-7.031(4) and (5)) establish general criteria applicable to all waters of the state at all times and specific criteria applicable to waters contained in 10 CSR 20-7.031, Tables G and H. Specific numeric *E. coli* bacteria criteria are given in Missouri's Water Quality Standards at 10 CSR 20-7.031(5)(C) and Table A1. For whole body contact recreation category A waters, *E. coli* concentrations during the recreational season (April through October) shall not exceed the geometric mean of 126 colony forming units (cfu) per 100 milliliters (mL) of water. For whole body contact recreation category B waters, *E. coli* concentrations during the recreational season shall not exceed the geometric mean of 206 cfu/100mL of water. For Secondary contact category waters, *E. coli* concentrations during the recreational season shall not exceed the geometric mean of 1,134 cfu/100mL of water.

3.3 Antidegradation Policy

Missouri's Water Quality Standards include the EPA "three-tiered" approach to antidegradation and may be found at 10 CSR 20-7.031(3).

Tier 1 – Protects public health, existing instream water uses, and a level of water quality necessary to maintain and protect existing uses. Tier 1 provides the absolute floor of water quality for all waters of the United States. Existing instream water uses are those uses that were attained on or after November 28, 1975, the date of EPA's first water quality standards regulations related to existing uses.

Tier 2 – Protects and maintains the existing level of water quality where it is better than applicable water quality criteria. Before water quality in Tier 2 waters can be lowered, there must be an antidegradation review consisting of: (1) a finding that it is necessary to accommodate important economic and social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and best management practices for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national and state resource waters. Such waters are identified in 10 CSR 20-7.031 Tables D and E. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality.

Waters in which a pollutant is at, near, or exceeds the water quality criteria are considered in Tier 1 status for that pollutant. Therefore, the antidegradation goals for the impaired streams in the Grand River watershed are to restore water quality to levels that meet water quality standards.

4. Defining the Problem

E. coli are bacteria found in the intestines of humans and warm-blooded animals and are used as indicators of potential fecal contamination and risk of pathogen-induced illness to humans. In accordance with Missouri's 2022 Listing Methodology Document, the whole body contact recreation

category A designated use for Grand River, Middle Fork Grand River, East Fork Grand River, and East Fork Locust Creek (WBID 610) are impaired because the geometric means of *E. coli* samples collected during the recreational season were greater than 126 cfu/100 mL in the most recent three years having available data with five or more samples.⁹ Whole body contact recreation category B designated use for Locust Creek and East Fork Locust Creek (WBID 608) are impaired because the geometric means of *E. coli* samples collected during the recreational season were greater than 206 cfu/100 mL in the most recent three years having available data with five or more samples. In East Fork Locust Creek (WBID 608), the secondary contact designated use criterion of 1,134 cfu/100 mL was also exceeded during the recreational season twice in the most recent three years having available data with five or more samples. Data available to support these listings are summarized in Table 5 and Figure 10. Data for recreational seasons having fewer than five samples are also presented, but the department did not use this data for making water quality assessment or 303(d) listing decisions.

High *E. coli* concentrations have also been observed in the upstream Middle Fork Grand River in Iowa. The geometric means are provided in Appendix A, Table A-1. Segments of the Middle Fork Grand River are identified as impaired by *E. coli* on Iowa's 2022 303(d) List.

Individual *E. coli* measurements are provided in Appendix A, Table A-2, to illustrate the nature of the impairment, but were not used in the calculation of TMDL loading capacities or allocations. Individual measurements can be used to estimate pollutant reduction targets, to target implementation activities, and to select appropriate best management practices (BMPs). Reduction targets for Grand River watershed streams are presented in a supplemental TMDL implementation strategies document available online at: dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

Table 5. Summary of available recreational season *E. coli* data for the impaired streams in the Grand River watershed¹⁰

Waterbody (WBID)	Recreation Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean* (cfu/100 mL)
Grand River (WBID 593)	2012	8	21	4,500	121.43
	2013	7	10	1,600	119.82
	2014	7	64	7,300	469.30
	2015	6	25	8,000	1,455.65
	2016	7	20	7,200	176.78
	2017	7	13	800	66.00
	2018	7	28	2,900	152.78
	2019	7	550	2,600	1,464.00
	2020	3	88	1,400	245.43

⁹ Listing Methodology documents are available online at: [Methodology for the Development of the 2022 Section 303\(d\) List in Missouri | Missouri Department of Natural Resources \(mo.gov\)](https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls).

¹⁰ *E. coli* data may be reported in units of most probably number (MPN) or colony forming units (cfu) depending upon the analysis method used. Data reported as cfu is an actual count of bacteria colonies, whereas MPN is a statistical approximation. Although differences may exist, they are often used interchangeably. For simplicity, and in order to maintain consistency with Missouri Water Quality Standards, all *E. coli* data in this TMDL are presented in units of cfu regardless of the methodology used.

Waterbody (WBID)	Recreation Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean* (cfu/100 mL)
Middle Fork Grand River (WBID 468)	2007	5	270	770	438.39
	2009	4	200	120,000	2,103.66
	2010	4	67	15,000	618.70
	2011	4	210	23,000	911.00
	2012	3	120	18,000	654.53
	2013	4	36	530	152.03
	2014	4	190	24,000	941.17
	2015	4	170	33,000	2,593.13
	2016	4	120	28,000	2,290.40
	2017	4	790	2,100	1,268.36
	2018	4	580	43,000	1,866.26
	2019	5	95	62,000	1,537.31
	2020	25	37	14,000	372.55
	2021	24	214	4,839	1,232.66
	2022	24	17	4,839	489.75
Waterbody (WBID)	Recreation Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean* (cfu/100 mL)
East Fork Grand River (WBID 457)	2002	3	40	800	146.37
	2003	4	130	490	242.17
	2004	3	120	22,000	1,283.01
	2005	3	67	900	343.13
	2017	5	272	4,839	703.28
	2019	6	131	4,839	346.90
Waterbody (WBID)	Recreation Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean* (cfu/100 mL)
Locust Creek (WBID 606)	2012	7	77	1,600	252.59
	2013	6	110	15,000	1,354.90
	2014	7	27	3,700	422.62
	2015	7	100	66,000	1,359.85
	2016	7	40	2,400	457.54
	2017	7	120	1,500	382.48
	2018	7	12	3,400	259.40
	2019	7	30	2,000	260.93
	2020	6	45	3,400	598.99
	2021	18	18	4,839	209.45
	2022	15	24	4,839	436.86

Waterbody (WBID)	Recreation Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean* (cfu/100 mL)
East Fork Locust Creek (WBID 608)	2006	5	365	1,986	715.00
	2007	10	816	4,484	1,223.91
	2018	11	65	4,839	599.20
	2019	11	344	4,839	2,425.01
	2020	12	461	4,839	2,127.51
<hr/>					
Waterbody (WBID)	Recreation Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean* (cfu/100 mL)
East Fork Locust Creek (WBID 610)	2006	10	22	816	161.69
	2007	10	22	4,839	411.02
	2021	10	57	4,839	656.15
	2022	9	235	2,419	1,221.20

* Although geometric means are presented for all years of available data, only years with a minimum of five samples were used for assessment purposes. For calculation purposes, and for consistency with Missouri's 303(d) listing methodologies, *E. coli* values recorded as greater-than (>) values were doubled and values recorded as less-than (<) values were halved.

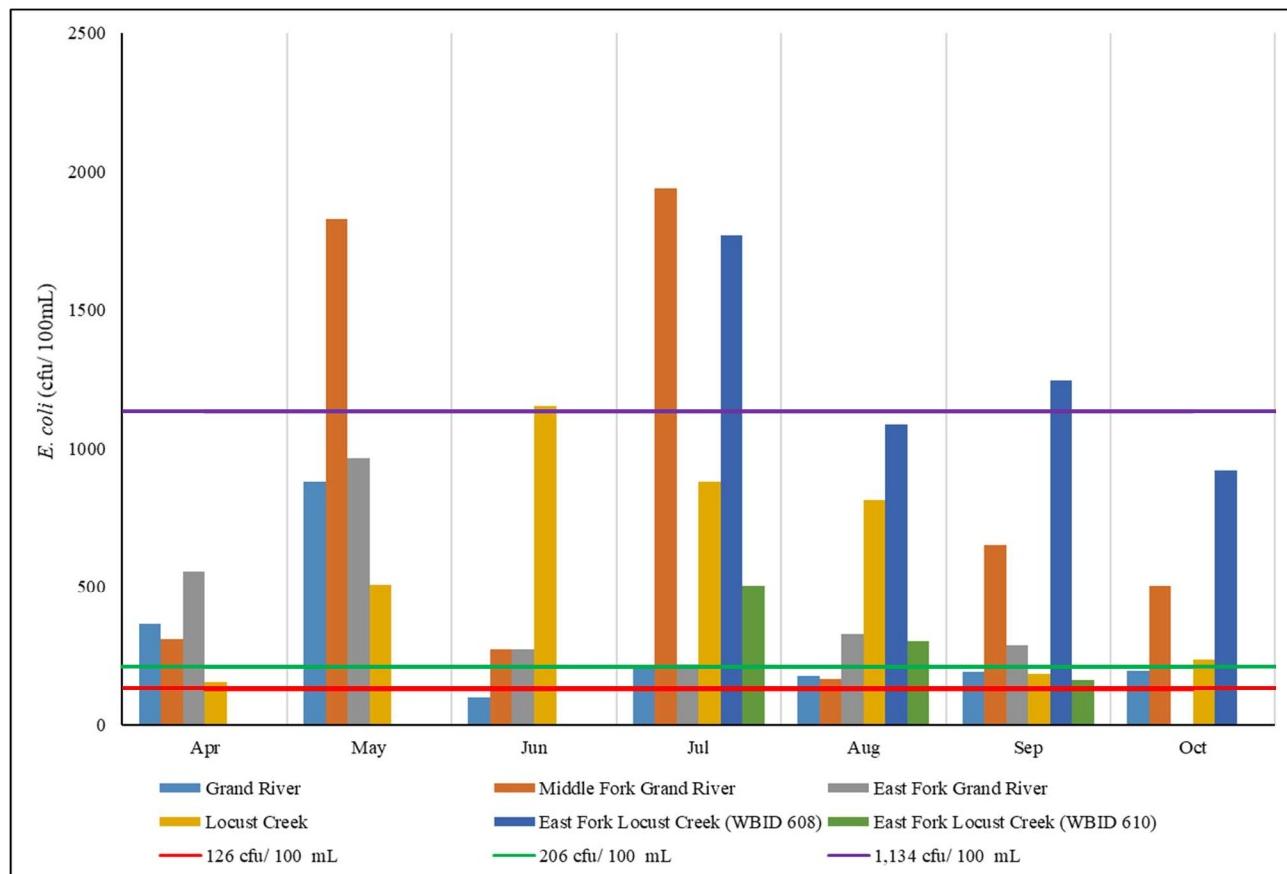


Figure 10. Geometric means for *E. coli* by month from 2002-2020

5. Source Inventory and Assessment

Point (typically regulated) and nonpoint (typically unregulated) sources may contribute to the elevated *E. coli* concentrations in the impaired water bodies. The following source inventory and assessment identifies and characterizes known, suspected, and potential sources of bacteria loading in the Grand River watershed. Sources of bacteria loading are identified and quantified to the extent that information is available.

5.1 Point Sources

Point sources are defined by Section 644.016(16) of the Missouri Clean Water Law and are regulated pursuant to the National Pollutant Discharge Elimination System (NPDES) through the Missouri State Operating Permit program.¹¹ A point source is defined as “any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. Point source does not include agricultural stormwater discharges and return flows from irrigated agriculture.” Based on this definition, point sources include domestic wastewater treatment facilities, industrial and commercial facilities, concentrated animal feeding operations (CAFOs), municipal separate storm sewer systems (MS4s), and stormwater discharges from industrial areas and construction sites. Illicit straight pipe discharges are also point sources but are illegal and therefore unpermitted. Pollutant loading from point sources is typically most evident during low-flow conditions when stormwater influences are lower or nonexistent. In Iowa, point sources are regulated by the Iowa Department of Natural Resources and are presented in this document for informational purposes only. For purposes of this TMDL, in accordance with 40 CFR 131.10(b), it is assumed that all point sources in Iowa are regulated through permits that are protective of all downstream uses and that will meet Missouri water quality standards at the state border. The locations of permitted point sources in the Grand River watershed are presented in Figure 11. Facility types and their expected contributions to the impaired stream are described individually in the following sections.

¹¹ The Missouri State Operating Permit program is Missouri’s program for administering the federal National Pollutant Discharge Elimination System (NPDES). Generally, the Clean Water Act requires all point sources that discharge pollutants to waters of the United States to obtain a NPDES permit. Issued and proposed operating permits are available online at: dnr.mo.gov/water/business-industry-other-entities/permits-certification-engineering-fees.

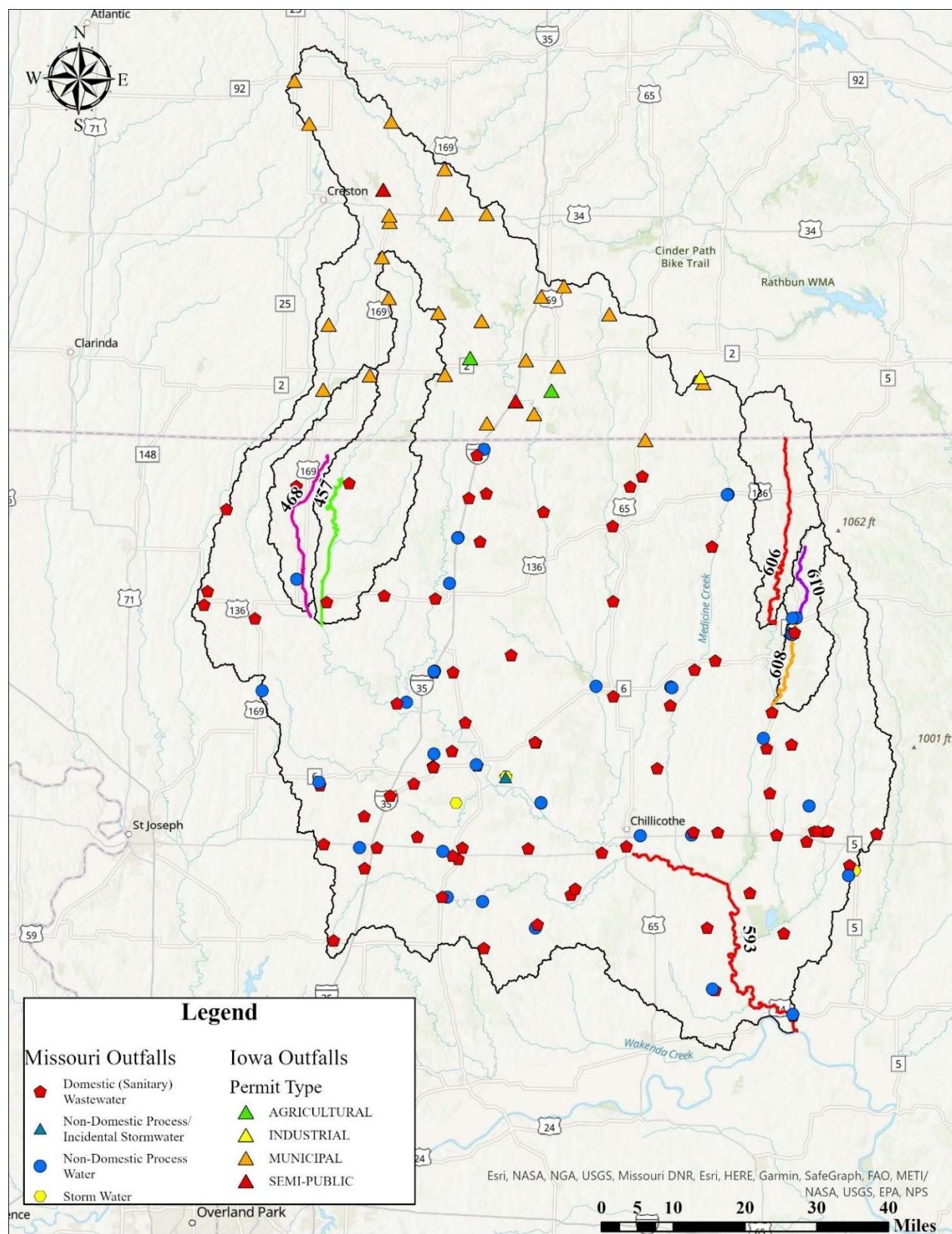


Figure 11. Permitted features and outfalls in the Grand River watershed¹²

¹² Each marker on the map represents an outfall. There may be multiple outfalls per facility.

5.1.1 Domestic Wastewater Treatment Facilities

Domestic wastewater is primarily household waste, including graywater and sewage. Domestic wastewater treatment facilities include both publicly owned (municipal and sewer districts) and privately owned facilities. Untreated or inadequately treated domestic wastewater discharges can be significant sources of bacteria to receiving waters (USEPA 1986). Facilities equipped with disinfection technologies discharge *E. coli* at very low concentrations and should not cause or contribute to bacteria impairments under normal operating conditions.

Table 6 lists the Missouri domestic wastewater dischargers in the Grand River watersheds. A considerable number of the facilities found in the Grand River watershed are lagoon systems without disinfection identified in their permits (generally ultraviolet or chlorination treatment). 10 CSR 20-7.015 requires recreational season *E. coli* limits for all domestic wastewater treatment facilities within two miles upstream of waters with whole body contact designated uses. Facilities without disinfection can be a potential source of *E. coli* loading if not operated in a manner to mitigate significant *E. coli* loading during the recreational season. Efforts to reduce facility loading to meet newly established wasteload allocations and to comply with applicable recreational criteria may include, but are not limited to, installation of disinfection infrastructure, effluent land application or irrigation, pump and haul operations, and seasonal batch discharging. All discharging facilities in Table 6 have operating permits containing final *E. coli* effluent limits and are expected to comply with such limits or be subject to department enforcement actions.

Table 6. Domestic wastewater treatment facilities in the Grand River watersheds¹³

Grand River (WBID 593)					
Permit No.	Facility Name	Treatment Type	Design Flow (ft ³ /s)	Disinfection	Expires (Mo/Day/Year) ¹⁴
MO0108227	Chillicothe WWTP	Mechanical Plant	4.64	Chlorination	6/30/2022
MO0039748	Trenton Municipal Utilities WWTP	Mechanical Plant	4.64	Chlorination	6/30/2024
MO0104299	Cameron WWTP	Mechanical Plant	2.48	None	12/31/2027
MO0137553	Brookfield WWTP	Mechanical Plant	1.55	UV	12/31/2022
MO0033502	Bethany WWTF	Mechanical Plant	0.78	UV	9/30/2021
MO0039721	Marceline WWTP	Mechanical Plant	0.70	Chlorination	9/30/2022
MO0027812	Gallatin WWTP	Mechanical Plant	0.46	UV	12/31/2021
MO0112704	Lathrop WWTF	Lagoon	0.36	None	2/28/2029
MO0028762	Princeton WWTF	Lagoon	0.30	Chlorination	12/31/2023
MO0043231	Stanberry WWTF	Mechanical Plant	0.29	UV	6/30/2027
MO0041106	Maysville WWTF	Lagoon	0.25	None	6/30/2022
MO0028061	Braymer WWTF	Lagoon	0.22	Chlorination	7/31/2027
MO0027600	Grant City West WWTF	Lagoon	0.22	None	3/31/2029
MO0129216	Twin Lakes WWTF	Lagoon	0.22	Seasonal Discharge	9/30/2023
MO0022080	Hamilton NE WWTF	Lagoon	0.20	None	3/31/2028
MO0032557	Brunswick WWTF	Lagoon	0.16	Chlorination	6/30/2028
MO0093891	Breckenridge WWTF	Lagoon	0.12	None	10/31/2028

¹³ Permit list compiled in and accurate as of May 2024.

¹⁴ Expired permits are administratively continued until the permit renewal process is completed. The permittee is obligated to adhere to all permit conditions even while the permit is expired.

MO0022071	Hamilton SE WWTF	Lagoon	0.11	None	3/31/2028
MO0100382	Pattonsburg WWTP	Lagoon	0.11	None	9/30/2026
MO0041114	Meadville WWTF	Lagoon	No Discharge	None	3/31/2023
MO0102709	Hale WWTF	Lagoon	0.10	None	9/30/2022
MO0048224	Ridgeway West WWTF	Lagoon	0.09	None	12/31/2021
MO0093491	Linneus WWTF	Lagoon	0.09	None	10/31/2028
MO0099856	Osborn WWTF	Lagoon	0.09	None	1/01/2029
MO0092932	Laclede WWTF	Lagoon	0.09	None	6/30/2027
MO0098663	Gilman City WWTF	Land Application	No Discharge	None	3/31/2024
MO0122467	Cainsville WWTF	Lagoon	0.08	None	6/30/2024
MO0051616	Browning WWTF	Lagoon	0.08	None	9/30/2027
MO0097608	Wheeling WWTF	Lagoon	0.08	None	9/30/2028
MO0111601	Altamont - Winston WWTF	Lagoon	0.08	None	3/31/2022
MO0135607	Bosworth WWTF	Lagoon	0.07	None	10/31/2028
MO0056057	Mercer WWTF	Lagoon	0.07	None	12/31/2023
MO0094692	Laredo WWTF	Lagoon	0.07	Chlorination	6/30/2023
MO0120405	Kingston WWTP	Mechanical Plant	0.06	UV	6/30/2022
MO0113930	Eagleville WWTF	Lagoon	0.06	None	12/31/2021
MO0095729	Galt WWTP	Lagoon	0.06	None	6/30/2023
MO0113026	Spickard WWTF	Lagoon	0.06	None	12/31/2023
MO0022063	Hamilton SW Municipal WWTF	Lagoon	0.06	None	3/31/2028
MO0125679	Utica WWTF	Lagoon	0.06	None	3/31/2027
MO0114685	New Hampton WWTF	Lagoon	0.06	None	2/28/2029
MO0087149	Jamesport WWTF	Lagoon	0.05	None	3/31/2028
MO0091146	Chula WWTF	Lagoon	0.05	None	9/30/2028
MO0094714	Mendon WWTF	Lagoon	0.05	None	12/31/2025
MO0130052	Cowgill WWTP	Lagoon	0.05	None	6/30/2027
MO0118591	Kidder WWTF	Mechanical Plant	0.04	None	9/30/2028
MO0117871	Newtown WWTF	Lagoon	0.04	None	3/31/2023
MO0125831	Purdin WWTF	Lagoon	0.04	None	4/30/2028
MO0125636	Parnell Lagoons WWTF	Lagoon	0.04	None	4/30/2028
MO0118010	Jameson WWTF	Lagoon	0.04	None	3/31/2022
MO0123081	Blythedale WWTF	Lagoon	0.03	None	12/31/2021
MO0130869	Ludlow WWTF	Lagoon	0.03	None	6/30/2022
MO0123960	Rockwood Creek Mobile Home Village WWTF	Lagoon	0.03	Chlorination	10/31/2027
MO0117862	Coffey WWTF	Lagoon	0.03	None	11/30/2027
MO0091600	Sumner WWTF	Lagoon	0.03	None	9/30/2027
MO0085910	Bucklin West WWTF	Lagoon	0.03	None	12/31/2022
MO0119750	Humphreys WWTF	Lagoon	0.02	None	1/31/2023
MO0132144	Elm Hills - Country Hills Estates WWTP	Sand/Rock Filter	0.02	None	11/30/2028
MO0138339	Brookfield Country	Land Application	0.02	None	10/31/2028

	Club WWTF				
MO0099074	Linn Co. R-I School District WWTF	Lagoon	No Discharge	None	9/30/2022
MO0091570	Trexmart 16 WWTF	Lagoon	0.01	None	9/30/2027
MO0081345	SW Livingston Co R1 School District WWTP	Sand/Rock Filter	0.01	None	6/30/2027
MO0133663	MoDOT Visitor Welcome Center WWTF	Land Application	No Discharge	None	12/31/2026
Middle Fork Grand River (WBID 468)					
Permit No.	Facility Name	Treatment Type	Design Flow (ft ³ /s)	Disinfection	Expires (Mo/Day/Year)
MO0027600	Grant City West WWTF	Lagoon	0.22	None	03/31/2022
East Fork Grand River (WBID 457)					
Permit No.	Facility Name	Treatment Type	Design Flow (ft ³ /s)	Disinfection	Expires (Mo/Day/Year)
MO0021466	Albany WWTF	Mechanical Plant	0.75	UV	03/31/2027
MO0130281	Allendale WWTP	Sand/Rock Filter	0.008	None	06/30/2022
East Fork Locust Creek (WBIDs 608, 610)					
Permit No.	Facility Name	Treatment Type	Design Flow (ft ³ /s)	Disinfection	Expires (Mo/Day/Year)
MO0048151	Milan WWTP	Mechanical Plant	1.08	UV	12/31/2022

In addition to wastewater discharges, domestic wastewater treatment facilities may also contribute bacteria loading from sanitary sewer overflows. Sanitary sewer systems convey residential wastewater, and in some cases commercial and industrial wastewater, to the domestic wastewater treatment facility. Sanitary sewer systems can handle limited amounts of inflow from stormwater and infiltration from groundwater but are typically not designed to collect large amounts of runoff from precipitation events. Overflows from sanitary sewer systems may result in elevated bacteria counts in nearby surface waters (USEPA 1996). Sanitary sewer overflows (SSOs) can be caused by high volume precipitation events and can also occur during dry weather due to blockages, line breaks, sewer defects, power failures, and vandalism. Sanitary sewer overflows can occur at any point in the collection system but are typically evident by overflowing manholes and backups into private residences. Such overflows may discharge directly to nearby waterways or may be restricted to terrestrial locations. These discharges are not authorized by the federal Clean Water Act or the Missouri Clean Water Law.

Approximately one hundred and fifty SSO or bypass events have been reported in the Grand River watershed over the last five years. Municipalities with significant SSO reporting include Brookfield WWTF (MO0137553) with fifty plus events, Bethany WWTF (MO0033502) reporting approximately thirty-five events, and Trenton WWTP ((MO0039748) reporting thirteen events within the last five years. While these events can be potential sources of *E. coli*, not all events reach surface waters or are significant in discharge volume. Missouri State Operating permits and 40 CFR Part 122.41(e) require permittees to properly operate and maintain their facility's collection systems. This is implemented through a special permit condition or schedule of compliance.

5.1.2 Site-Specific Permitted Industrial and Commercial Facilities

Industrial and commercial facilities discharge process water used or generated during mining, manufacturing, or food processing activities, and may also include landfills. Mining and manufacturing facilities are not expected to cause or contribute to bacteria impairments. Food processing wastewater may contain bacteria. Table 7 provides facility details for only site-specific permitted industrial or commercial facility in the Grand River watershed, specifically located in the East Fork Locust Creek (WBID 610) subwatershed. Smithfield Fresh Meats (MO0115487) is a meat processing facility located in the headwaters of East Fork Locus Creek, the facility currently disinfects effluent discharge using ultraviolet or chlorination treatment. In addition to the one site-specific permit, there are numerous general permits for industrial and commercial facilities. General permits are discussed in Section 5.1.5.

Table 7. Industrial or commercial facilities in the Grand River watershed

Permit No.	Facility Name	Treatment Type	Design Flow (ft ³ /s)	Disinfection	Expires (Mo/Day/Year)
MO0115487	Smithfield Fresh Meats	Mechanical Plant	1.67	UV/Chlorination	01/31/2025

5.1.3 Concentrated Animal Feeding Operations

Animal waste generated from CAFOs can be a source of bacteria to water bodies (Rogers & Haines 2005). Pursuant to 10 CSR 20-6.300, permits are required for CAFOs that confine and feed or maintain more than 1,000 animal units for 45 days or more during any 12-month period.¹⁵ Permits may be required for facilities with fewer animal units if pollutants are discharged directly into waters of the state or other water quality issues are discovered. In Missouri, CAFOs operate under site-specific permits or one of two general permits (MOG01 or MOGS1). The MOGS1 permit does not authorize any direct discharges. The MOG01 permit allows discharge only in the event of weather that exceeds the criteria of a catastrophic storm, and only authorizes discharge of the portion of stormwater flow that exceeds the design storm event, which includes the direct precipitation and runoff from the 25-year, 24-hour storm event. These discharges are not expected to be significant contributors of *E. coli* to surface waters because they are rare and temporary in nature, and may only occur during the defined catastrophic storm events that generally result in high flows that are infrequently met or exceeded.

There are 65 CAFOs located in the Missouri portion of the Grand River watershed of varying class sizes¹⁶. Table 8 presents facility information for the existing CAFOs within the Grand River watersheds. Animal waste applied on areas under the control of a CAFO are subject to conditions found in the permit, which include a requirement for the CAFO to develop a nutrient management plan. Section 640.760 Revised Statutes of Missouri (RSMo) establishes setback distances for

¹⁵ As defined by 10 CSR 20-6.300(1)(B)2, an animal unit is a unit of measurement to compare various animal types at an animal feeding operation. One (1) animal unit equals the following: 1.0 beef cow or feeder, cow/calf pair, veal calf, or dairy heifer; 0.5 horse; 0.7 mature dairy cow; 2.5 swine weighing over 55 pounds; 10 swine weighing less than 55 pounds; 10 sheep, lamb, or meat and dairy goats; 30 chicken laying hens or broilers with a wet handling system; 82 chicken laying hens without a wet handling system; 55 turkeys in grow-out phase; 125 chicken broilers, chicken pullets, or turkey poultts in brood phase without a wet handling system.

¹⁶ An operation's "class size" is a category that is based upon the total number of animal units confined at an operation. The Class IC, IB, and IA are categories that start at 1,000, 3,000, and 7,000 animal units respectively, all of which are required by state regulation to obtain a permit. (1,000 animal units is equal to 2,500 swine; 100,000 broilers; 700 dairy cows; or 1,000 beef steers).

surface application of liquefied animal waste from a CAFO by a third party.¹⁷ Although application fields are potential sources of *E. coli*, permits prohibit direct discharge or runoff from land application into water bodies. Therefore when all permit requirements are met, CAFOs are not expected to be significant contributors of bacteria loading through direct discharge to the Grand River watershed. CAFOs violating their permit conditions as they relate to discharge or land application are potential sources of *E. coli* and are subject to department enforcement action.

Table 8. Concentrated Animal Feed Operations in the Grand River Watersheds

Grand River (WBID 593)					
Permit No.	Facility Name	County	Class Size ¹⁴	Treatment	Expires ¹⁸ (Mo/Day/Year)
MO0118168	Smithfield, Somerset Farm	Mercer	Class IA	Land Application	2/28/2022
MO0118494	Smithfield, Locust Ridge Farm	Sullivan	Class IA	Land Application	2/28/2022
MO0118745	Smithfield, Badger/Wolf Brantley Farm	Mercer	Class IA	Land Application	2/28/2022
MO0118460	Smithfield, Homan Farm	Gentry	Class IA	Land Application	12/31/2021
MOGS10002	Chuck Weldon Farm	Daviess	Class IC	Land Application	2/13/2028
MOGS10016	Chad Crawford	Grundy	Class IC	Land Application	2/13/2028
MOGS10017	Mike Henke Finisher Facility	Mercer	Class IC	Land Application	2/13/2028
MOGS10019	Mike Henke B and G Facility	Mercer	Class IC	Land Application	2/13/2028
MOGS10074	Hall Farms	Sullivan	Class IC	Land Application	2/13/2028
MOGS10085	David Brown South Farm	Sullivan	Class IC	Land Application	2/13/2028
MOGS10084	Travis Carmack Farms LLC	Sullivan	Class IC	Land Application	2/13/2028
MOGS10086	David Brown Farms - North	Sullivan	Class IC	Land Application	2/13/2028
MOGS10102	WFHF, LLC	Daviess	Class IB	Land Application	2/13/2028
MOGS10126	Rexing Farms Inc	Daviess	Class IC	Land Application	2/13/2028
MOGS10130	James and Eddie Rhoades	Putnam	Class IC	Land Application	2/13/2028
MOGS10141	Betz Farms Inc	Grundy	Class IB	Land Application	2/13/2028

¹⁷ Section 640.760 RSMo requires all third party applicators of liquefied animal waste from CAFOs to maintain the following minimum setback distances: 50 feet from a property boundary, 300 feet from any public drinking water lakes, 300 feet from any public drinking water well or intake structure, 100 feet from any perennial and intermittent streams without vegetation abutting such streams, and 35 feet from any perennial and intermittent streams with vegetation abutting such streams.

¹⁸ Expired permits are administratively continued until the permit renewal process is completed. The permittee is obligated to adhere to all permit conditions even while the permit is expired.

MOGS10114	United Hog Systems/Z4-Bosworth SEW	Carroll	Class IC	Land Application	2/13/2028
MOGS10193	Pine View Pork	Gentry	Class IB	Land Application	2/13/2028
MOGS10194	Leeper Farms	Daviess	Class IC	Land Application	2/13/2028
MOGS10195	Kendall Smith	Gentry	Class IC	Land Application	2/13/2028
MOGS10207	Newlin Farms	Linn	Class IC	Land Application	2/13/2028
MOGS10150	Don Davis	Sullivan	Class IC	Land Application	2/13/2028
MOGS10151	Brad Vogel Farm	Mercer	Class IC	Land Application	2/13/2028
MOGS10222	Jack Wells	Putnam	Class IC	Land Application	2/13/2028
MOGS10159	Henke Brothers Hogs	Mercer	Class IC	Land Application	2/13/2028
MOGS10318	Shield Ag Enterprises, LLC	Mercer	Class IC	Land Application	2/13/2028
MOGS10293	2-M Farms	Sullivan	Class IC	Land Application	2/13/2028
MOGS10298	Don Davis	Mercer	Class IC	Land Application	2/13/2028
MOGS10302	Smith Nursery	Sullivan	Class IC	Land Application	2/13/2028
MOGS10406	Ireland Farms	Livingston	Class IC	Land Application	2/13/2028
MOGS10320	D and D Buckler farm	Mercer	Class IC	Land Application	2/13/2028
MOGS10306	Ronald Faulkner Farm	Sullivan	Class IB	Land Application	2/13/2028
MOGS10440	Old Oak Sow Farm	Daviess	Class IC	Land Application	2/13/2028
MOGS10442	Bentwood - Dry Pond	Harrison	Class IC	Land Application	2/13/2028
MOGS10456	Davis Farms	Sullivan	Class IC	Land Application	2/13/2028
MOGS10475	Walnut Grove Pork, LTD	Harrison	Class IC	Land Application	2/13/2028
MOGS10518	CJ Pork, LLC	Mercer	Class IC	Land Application	2/13/2028
MOGS10520	Trenton Farms RE, LLC	Grundy	Class IC	Land Application	2/13/2028
MOGS10071	Hepler Farms	Sullivan	Class IC	Land Application	2/13/2028
MOG010124	Smithfield Hog Production, Sharp Farm	Daviess	Class IC	Land Application	2/25/2023
MOG010712	Smithfield, Summers Nursery	Mercer	Class IB	Land Application	2/25/2023
MOG010422	Smithfield Hog, Cypress Creek	Daviess	Class	Land	2/25/2023

	Facility		IB	Application	
MOG010036	Smithfield, Denver Miller Farm	Mercer	Class IC	Land Application	2/25/2023
MOG010475	Smithfield, Hickory Creek Farm	Daviess	Class IB	Land Application	2/25/2023
MOGS10077	Shafer Farms	Sullivan	Class IC	Land Application	2/13/2028
MOG010103	Johnson Land and Development Co.	Daviess	Class IB	Land Application	2/25/2023
MOG010037	Smithfield Hog Production, Overlook Farm	Sullivan	Class IC	Land Application	2/25/2023
MOG010771	Smithfield, Scott Colby Farm	Daviess	Class IB	Land Application	2/25/2023
MOG010034	Smithfield, Wade Webster Farm	Mercer	Class IB	Land Application	2/25/2023
MOG010864	Smithfield, Peach-Perkins Farm	Mercer	Class IB	Land Application	2/25/2023
MO0118753	Smithfield, Hedgewood Farm	Mercer	Class IA	Land Application	9/30/2023
MOGS10192	Two Rivers Cattle Feeders	Chariton	Class IB	Land Application	2/13/2028
MOG010149	Jerald Utt Farm	DeKalb	Class IC	Land Application	2/25/2023
MOGS10333	Webb and Gates Farms, L.L.C.	Daviess	Class IC	Land Application	2/13/2028
MOGS10604	Travis Sowers	Chariton	Class IC	Land Application	2/13/2028
MOGS10610	Nalle Piggery at Cypress Creek, LLC	Daviess	Class IC	Land Application	2/13/2028
MOGS10609	Nalle Piggery at Long Branch LLC	Daviess	Class IC	Land Application	2/13/2028
MOGS10225	United Hog Systems -Z5 Sow Farm	Caldwell	Class IC	Land Application	2/13/2028
MOG010035	Smithfield Hog Production, Wiles Farm	Mercer	Class IC	Land Application	2/25/2023
MOGS10081	Lucas Wells	Sullivan	Class IC	Land Application	2/13/2028

Middle Fork Grand River (WBID 468)

Permit No.	Facility Name	County	Class Size ¹⁴	Treatment	Expires (Mo/Day/Year)
MO0118451	Smithfield, Ruckman Farm	Gentry	Class IA	Land Application	12/31/2021
MOGS10434	Big Hill - Sow and Nursery	Gentry	Class IC	Land Application	1/28/2023

East Fork Grand River (WBID 457)

Permit No.	Facility Name	County	Class Size ¹⁴	Treatment	Expires (Mo/Day/Year)
MOGS10441	Windmill Site - Sow and Nursery	Harrison	Class IC	Land Application	2/13/2028

Locust Creek (WBID 606)

Permit No.	Facility Name	County	Class	Treatment	Expires
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			Size¹⁴		(Mo/Day/Year)
MO0118761	Smithfield, Terre Haute Farm	Putnam	Class IA	Land Application	2/28/2022
MOGS10217	Jack and David Guffey	Putnam	Class IC	Land Application	2/13/2028

5.1.4 Municipal Separate Storm Sewer Systems

Municipal separate storm sewer systems (MS4s) are stormwater conveyance systems owned by a public entity that are not part of a sanitary sewer system, a combined sewer system, or part of a domestic wastewater treatment facility. Federal regulations issued in 1990 require that discharges from MS4s be regulated by permits if the population of a municipality, or in some cases a county, is 100,000 or more (Phase I). As of 1999, federal regulations require permits for discharges from small MS4s that are located within a U.S. Census Bureau defined urban area or are required to hold a MS4 permit based on other criteria by the permitting authority (Phase II). At the time of the 2020 census, the U.S. Census Bureau did not designate any areas in the Missouri portion of the watershed as urban areas. Currently there are no regulated MS4s in the Grand River watershed within Missouri. Unregulated runoff from developed areas is discussed in Section 5.2.2.

5.1.5 Other General Permitted Wastewater and Stormwater Discharges

General permits are issued for certain wastewater (MOG) and stormwater (MOR) discharges based on the type of activity and are intended to be flexible enough to allow for ease and speed of issuance, but must also protect water quality. General wastewater and stormwater permits are issued for activities similar enough to be covered by a single set of requirements. Table 9 lists the effective general and stormwater discharge permits in the Grand River watershed as of February 2023. Permits associated with construction or land disturbance activities (MORA) are temporary. The number of permits of this type may vary in any given year.

Existing and future activities for which general wastewater or stormwater permits are issued are expected to be conducted in compliance with all permit conditions including monitoring requirements and discharge limitations. Permit conditions are intended to protect the designated uses of all water bodies within the watershed. Permit conditions are intended to protect the designated uses of all water bodies within the watershed. For the facilities identified in Table 9, activities conducted in accordance with these general wastewater and stormwater permit requirements are not expected to contribute *E. coli* loads in amounts substantial enough to cause or contribute to surface water impairments. Per 10 CSR 20-6.010(13)(C), if at any time the department determines that a general permit is not providing adequate water quality protection, the department may require the owner or operator of a permitted site or activity to obtain a site-specific operating permit. It should be noted general permit number MOG22 is issued for small meat processing facilities. Waste byproducts from these facilities have potential to contribute to *E. coli* loading. Facilities under MOG22 general permits are no discharge and are required to land apply excess lagoon freeboard, therefore if a facility meets all requirements of the relevant subdivision in the master general permit for small meat processors, it should not be a significant contributor of *E. coli* to the Grand River watershed.

Table 9. General (MOG) and stormwater (MOR) permitted facilities in the Grand River watershed in Missouri

Grand River (WBID 593)				
Permit No.	Facility Name	County	Permit Type	Expires (Mo/Day/Year) ¹⁹
MOR80F014	Chillicothe Municipal Airport	Livingston	Airports	11/27/2027
MOR80F017	Trenton Municipal Airport	Grundy		11/27/2027
MOR80H012	Hope Haven Industries, Inc.	Livingston		8/31/2024
MOR130102	Coffey Feed Mill	Daviess	Multiple Industry	10/22/2028
MOR130083	Nestle Professional Trenton MO	Grundy		10/22/2028
MOR130076	Lucerne Feed Mill	Putnam		10/22/2028
MOR130091	Milbank Mills Inc	Livingston		10/22/2028
MOR130084	North Star Feeds, LLC	Chariton		10/22/2028
MOG500183	J and D Sands LLC	Livingston		5/22/2027
MOG500202	Pierce Sand and Gravel Stanberry	Gentry	Sand And Gravel Washing	5/22/2027
MOG500116	Stoner Sand	Harrison		5/22/2027
MOG490046	Bethany Quarry	Harrison		4/30/2027
MOG491092	Big Creek Quarry	Harrison	Limestone Quarries	4/30/2027
MOG491060	Blue Mound Quarry	Livingston		4/30/2027
MOG490611	Braymer Quarry	Caldwell		4/30/2027
MOG490678	Cameron Concrete	Clinton		4/30/2027
MOG490002	Cameron Quarry	DeKalb		4/30/2027
MOG490810	City of Trenton Street Department	Grundy		4/30/2027
MOG490494	Chillicothe Ready Mix	Livingston		4/30/2027
MOG490663	Edinburg Quarry	Grundy		4/30/2027
MOG491322	Flory's Rock and Lime, L.L.C.	Livingston		4/30/2027
MOG490048	Gallatin Quarry	Daviess		4/30/2027
MOG490044	Jeffries Quarry	Harrison		4/30/2027
MOG490003	Kingston Quarry	Caldwell		4/30/2027
MOG490371	Leo O'Laughlin Inc Marceline	Linn		4/30/2027
MOG491510	Mallinson Quarry	Mercer		4/30/2027
MOG490027	Mercer Quarry	Mercer		4/30/2027
MOG490610	Pattensburg Quarry	Daviess		4/30/2027
MOG490028	Princeton Quarry	Mercer		4/30/2027
MOG490047	Route C Quarry	Daviess		4/30/2027
MOG490481	Stanberry Quarry	Gentry		4/30/2027
MOG491403	Swan Land Improvement of Missouri LLC	Harrison		4/30/2027
MOG490870	Thompson Bros. Ready-Mix Concrete	Linn		4/30/2027

¹⁹ Expired permits are administratively continued until the permit renewal process is completed. The permittee is obligated to adhere to all permit conditions even while the permit is expired.

Grand River (WBID 593)				
Permit No.	Facility Name	County	Permit Type	Expires (Mo/Day/Year)¹⁹
MOG491549	Trager Limestone, L.L.C.	Daviess		4/30/2027
MOG490828	Trager Limestone, L.L.C.	Caldwell		4/30/2027
MOG490010	Trenton Quarry	Grundy		4/30/2027
MOG491110	Twin States Sand and Gravel LLC	Sullivan		4/30/2027
MOG490818	Coburn Quarry	Grundy		4/30/2027
MOR80H065	Bethany Transfer Station	Harrison	Solid Waste Transfer	8/31/2024
MOR80H012	Hope Haven Industries, Inc.	Livingston		8/31/2024
MOR203495	CMC Rebar Polo	Caldwell	Fabricated Metal	8/31/2024
MOR203353	Brookfield Fabricating Corporation	Linn		8/31/2024
MOR203333	WireCo WorldGroup Chillicothe Facility	Livingston		8/31/2024
MOR203086	Modine Manufacturing Company	Grundy		8/31/2024
MORA21982	Badger Wolf	Mercer		2/7/2027
MORA22148	Cameron WWTP	DeKalb		2/7/2027
MORA22812	Casey's General Stores	Livingston		2/7/2027
MORA23013	Chillicothe	Livingston		2/7/2027
MORA23069	Chillicothe Elementary School	Livingston		2/7/2027
MORA21325	First Baptist Church of Lathrop	Clinton		2/7/2027
MORA20019	Greenridge Subdivision	Clinton		2/7/2027
MORA19728	Lathrop East Switching Station	Clinton		2/7/2027
MORA20869	Little Creek Culverts	Harrison	Construction or Land Disturbance	2/7/2027
MORA20860	Little Otter Creek Reservoir	Caldwell		2/7/2027
MORA21695	Max Curnow Dealership	Livingston		2/7/2027
MORA19836	NS Bridge S-189.19	Chariton		2/7/2027
MORA23068	Roeslein - Badger Wolf	Mercer		2/7/2027
MORA22532	Roeslein - Badger Wolf	Mercer		2/7/2027
MORA21505	Roeslein - Scott Colby	Daviess		2/7/2027
MORA14647	Stanberry WWTF	Gentry		2/7/2022
MORA21745	Timber Villas Phase II L.P.	Livingston		2/7/2027
MORA21745	Timber Villas Phase II L.P.	Livingston		2/7/2027
MORA21745	Timber Villas Phase II L.P.	Livingston		2/7/2027
MOR23E020	American Energy Producers Inc	Carroll	Biodiesel Manufacturing	5/31/2018
MOG220061	Ben's Custom Butchering	Harrison	Small Meat Processors	6/30/2027
MOG220086	From the Farm LLC	Grundy		6/30/2027
MOG220085	Greg Brown Slaughter Facility	Daviess		6/30/2027
MOG220075	Mast Pastured Poultry	Daviess		6/30/2027
MOG220088	Purdin Poultry Processing	Linn		6/30/2027
MOG220077	Rains Natural Meats	Daviess		6/30/2027
MOG220087	Stoney Ridge Custom	Daviess		6/30/2027

Grand River (WBID 593)				
Permit No.	Facility Name	County	Permit Type	Expires (Mo/Day/Year) ¹⁹
	Processing			
MOG220076	Sunrise Meats L.L.C.	Mercer		6/30/2027
MOG220033	Warner Locker Inc	DeKalb		6/30/2027
MOG220092	Yoder's Sausage Kitchen LLC	Daviess		6/30/2027
MOR80C058	Reidlinder, Inc.	Nodaway	Motor Freight Transportation	11/30/2022
MOR80C643	Union Pacific Railroad Company - Trenton	Grundy		11/30/2022
MOR60A435	Allstate Auto Salvage and Sales	DeKalb	Motor Vehicle Salvage	12/11/2023
MOR60A458	Anderson Auto Salvage	Livingston		12/11/2028
MOR60A081	Cameron Auto Salvage	DeKalb		12/11/2028
MOR60A043	Frontier Auto and Truck Parts LLC	Grundy		12/11/2028
MOR60A392	Hobbs Truck and Equipment	Grundy		12/11/2028
MOG350055	MFA Oil Bulk Plant - Maysville	DeKalb	Petroleum Storage <250,000 gallons	9/17/2027
MOG350102	MFA Oil Bulk Plant - Stanberry	Gentry		9/17/2027
MOG350056	MFA Oil Bulk Plant Bethany	Harrison		9/17/2027
MOG350063	MFA Oil Bulk Plant Brookfield	Linn		9/17/2022
MOG350067	MFA Oil Bulk Plant Brunswick	Chariton		9/17/2027
MOG350084	MFA Oil Bulk Plant Chillicothe	Livingston		9/17/2027
MOG350059	MFA Oil Bulk Plant Gallatin	Daviess		9/17/2027
MOG350060	MFA Oil Bulk Plant Hamilton	Caldwell		9/17/2027
MOG350058	MFA Oil Bulk Plant Pattonsburg	Daviess		9/17/2027
MOG350228	MFA Oil Bulk Plant Princeton	Mercer		9/17/2027
MOG350101	MFA Oil Bulk Plant Ridgeway	Harrison		9/17/2027
MOG350295	MFA Oil Bulk Plant Trenton	Grundy		9/17/2027
MOG350307	MFA Oil Petro Card Browning	Linn		9/17/2027
MOG350199	Ray-Carroll Fuels, LLC - Brunswick	Chariton		9/17/2027
MOG490704	Bethany Ready Mix	Harrison	Ready-Mixed Concrete	4/30/2027
MOG491554	Emery Sapp and Sons Plant #6	Sullivan		4/30/2027
MOG491470	Jamesport Concrete	Daviess		4/30/2027
MOG490515	Penny's Concrete, Inc.	Caldwell		4/30/2027
MOG490885	Penny's Concrete, Inc. Chillicothe	Livingston		4/30/2027
MOG490496	Trenton Ready Mix	Grundy	Refuse Systems	4/30/2027
MOG490547	Trenton Ready Mix North Side	Grundy		4/30/2027
MOR80H162	Green Hill Recyclers Company	Linn		8/31/2024
MOR80H072	R and W Container LLC	Caldwell		8/31/2024
MOR80H167	Rapid Removal Transfer	Grundy		8/31/2024

Grand River (WBID 593)				
Permit No.	Facility Name	County	Permit Type	Expires (Mo/Day/Year)¹⁹
	Station, LLC			
MOR22A058	Willie Hibner Sawmill	Livingston	Lumber and Wood	9/16/2024
MOR23D170	A 1 Hauler LLC	DeKalb	Plastics Products	5/9/2027
MOR23D174	Rubber Innovations LLC	DeKalb		5/9/2027
MOR23D132	Sonoco Plastics	Livingston		5/9/2027
East Fork Grand River (WBID 457)				
Permit No.	Facility Name	County	Permit Type	Expires (Mo/Day/Year)
MOR203136	Johnson Controls, Inc.	Gentry	Fabricated Metal	8/31/2024
MOG350270	MFA Oil Petro Card - Albany	Gentry	Petroleum Storage <250,000 gallons	9/17/2027
MOG500203	Pierce Sand and Gravel Albany	Gentry	Sand And Gravel Washing	5/22/2027
Locust Creek (WBID 606)				
Permit No.	Facility Name	County	Permit Type	Expires (Mo/Day/Year)
MORA22098	Buckeye Partners, LP UM760IM MP 121.18	Putnam	Construction or Land Disturbance	2/7/2027
MORA21514	East Locust Creek Reservoir	Sullivan		2/7/2027
East Fork Locust Creek (WBID 608, 610)				
Permit No.	Facility Name	County	Permit Type	Expires (Mo/Day/Year)
MOR130079	Simmons Animal Nutrition, Inc. - Milan	Sullivan	Multiple Industry	10/22/2028
MOG490681	Milan Ready Mix, LLC	Sullivan	Limestone Quarries	4/30/2027
MORA12110	Drake Bradshaw	Sullivan	Construction or Land Disturbance	2/7/2022
MOG350254	MFA Oil Company Milan Bulk Plant	Sullivan	Petroleum Storage <250,000 Gallons	9/17/2027

5.1.6 Illicit Straight Pipe Discharges

Illicit straight pipe discharges of domestic wastewater are also potential sources of bacteria. These types of sewage discharges bypass treatment systems, such as septic tanks or sanitary sewers, and discharge directly to a stream or an adjacent land area (Brown and Pitt 2004). Illicit straight pipe discharges are illegal and are not authorized by the federal Clean Water Act or the Missouri Clean Water Law. At present, there are no data about the presence or number of illicit straight pipe discharges in the Grand River watershed. For this reason, it is unknown if any straight pipe discharges are present in the watershed and to what significance they may contribute bacteria loads. Due to the illegal nature of these discharges, any identified illicit straight pipe discharges must be eliminated.

5.2 Nonpoint Sources

Nonpoint sources are diffuse sources with no discernible, confined, or discrete conveyance, and include all categories of discharge that do not meet the definition of a point source. Nonpoint sources are not regulated by the federal Clean Water Act and are exempt from department permit requirements by state regulation 10 CSR 20-6.010(1)(B)1. Nonpoint source pollutants are typically transported by stormwater runoff, which is minor or negligible during dry weather conditions. Although there are no specific *E. coli* data to indicate contributions from specific nonpoint sources, common nonpoint sources that have the potential to contribute bacteria loading to surface waters include agricultural lands, onsite wastewater treatment (septic) systems, and developed areas that do not have regulated storm sewer systems. Agricultural lands associated with land application of wastewater or sludge from permitted facilities, including CAFOs, are also considered nonpoint sources, so long as the activities meet agricultural practices and agronomic land application rates, without direct discharge from land application activities. Nonpoint source pollution can also result from natural background contributions, such as wildlife waste. Streams with little to no riparian buffer are most susceptible to nonpoint source pollution. The department provides guidance and examples of BMPs to help reduce pollutant loading from nonpoint sources in the supplemental Grand River Nonpoint Source Implementation Strategies document at: <https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdl>. These actions are voluntary and not a requirement of this TMDL. However, efforts to reduce pollutant loading from any potential nonpoint source contributor in the watershed is encouraged and will aid in meeting the water quality goals of this TMDL.

5.2.1 Agricultural Lands

Croplands, pasturelands, and low-density animal feeding operations are potential sources of bacteria in surface waters. Bacteria are transported in runoff from areas fertilized with animal waste and where livestock are present. Runoff can result from precipitation or excessive irrigation. Soil and Water Conservation Districts provide funding and guidance for the development of nutrient management plans for unregulated private lands. Areas where nutrient management plans guide animal waste application and where BMPs are used to reduce soil erosion contribute less bacteria to surface waters than unmanaged areas. Although grazing areas are typically well vegetated, livestock tend to congregate near feeding and watering areas, which can create barren areas that are susceptible to erosion (Sutton 1990). Additionally, livestock that are not excluded from streams can defecate while wading and thus deposit bacteria directly into the waterway.

As noted in Section 2.4 of this document, agricultural areas (cropland and pastureland) account for 74.0 percent of the watershed. Aside from livestock present in permitted CAFOs, the exact type and number of livestock present in the Grand River watershed is unknown. An estimate of the number of cattle in the Missouri portion of the watershed was calculated by using the available land cover data in Section 2.4 and county cattle population numbers provided in the U.S. Department of Agriculture's 2017 Census of Agriculture (NASS 2017). Using the total number of cattle in Worth, Gentry, DeKalb, Clinton, Harrison, Daviess, Caldwell, Ray, Mercer, Grundy, Livingston, Carroll, Putnam, Sullivan, Linn, Chariton, Nodaway, and Andrew counties and the proportion of each county's area of pastureland in the watershed to the total area of pastureland in each county, it is

estimated that there are 561,567 cattle in the Missouri side of the Grand River watershed (Table 10).²⁰

Table 10. Cattle population estimates for pasture areas in the Missouri side of the Grand River watershed

County	Watershed	Cattle No. County	Pastureland (Sq. Mi)	Pastureland in Watershed (Sq. Mi)	Pastureland in Watershed/ Total Pastureland	Watershed Cattle No.
Worth	Grand River	14,091	131.16	29.36	22.38%	3,154
	M. F. Grand River			52.07	39.70%	5,594
	E. F. Grand River			40.53	30.90%	4,354
Gentry	Grand River	34,596	211.51	147.33	69.66%	24,098
	M. F. Grand River			20.75	9.81%	3,394
	E. F. Grand River			37.48	17.72%	6,130
DeKalb	Grand River	32,279	191.14	121.56	63.30%	20,529
Clinton	Grand River	25,115	176.03	35.76	20.31%	5,102
Harrison	Grand River	43,136	337.59	290.31	85.99%	37,095
	E. F. Grand River			47.28	14.01%	6,041
Daviess	Grand River	25,202	226.65	226.65	100.00%	25,202
Caldwell	Grand River	30,004	211.50	194.33	91.88%	27,658
Ray	Grand River	26,397	210.36	11.64	5.53%	1,461
Mercer	Grand River	20,603	219.46	219.46	100.00%	20,603
Grundy	Grand River	20,992	164.80	164.80	100.00%	20,992
Livingston	Grand River	15,064	149.25	149.25	100.00%	15,604
Carroll	Grand River	27,520	191.88	115.44	60.16%	16,557
Putman	Grand River	47,865	253.11	54.48	21.52%	10,303
	Locust Creek			64.29	24.50%	12,158
	E. F. Locust Creek			1.79	0.71%	339
Sullivan	Grand River	44,534	361.68	206.92	57.21%	25,478
	Locust Creek			27.40	7.58%	3,374
	E. F. Locust Creek			66.52	18.39%	8,191
Linn	Grand River	54,512	291.78	271.60	93.08%	50,742
Chariton	Grand River	39,695	222.76	49.54	22.24%	8,828
Nodaway	Grand River	42,965	269.83	34.02	12.61%	5,147
Andrew	Grand River	16,997	107.36	1.45	1.35%	230
Total		561,567	3,928	2,324	59.16%	318,422

Other types of livestock such as horses and sheep may also be contributing bacteria loads in the Grand River watershed. The number and distribution of other animals in the watershed cannot be estimated from available data. Due to the large proportion of land in the watershed used for agricultural purposes, agricultural stormwater runoff is a potential contributor of *E. coli* loading to the Grand River. Voluntary BMPs that may reduce *E. coli* loading from agricultural areas are discussed in the supplemental Implementation Strategies document located at:

²⁰ This analysis assumes all areas identified as hay and pasture are being used for cattle grazing and that cattle are evenly distributed among those areas. Additionally, although some animals may be confined in some areas, for purposes of this estimation the entire cattle population was assumed to be grazing on pasture areas.

dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

5.2.2 Runoff from Developed Areas

As discussed in Section 5.1.4, there are no regulated MS4s in the Grand River watershed. Developed areas where stormwater discharges are not regulated through MS4 permits are potential nonpoint sources of *E. coli* loading. *E. coli* contaminated runoff can come from heavily paved areas and areas where soil erosion is common. Common sources of *E. coli* contamination in urban stormwater have been documented as originating from birds, dogs, cats, and rodents (Burton and Pitt 2002). Irrigation runoff from residential lawns where pet wastes are present may also contribute *E. coli* loads to surface waters.

As presented in Section 2.4, developed areas cover small portions of the total Grand River watershed. For the Grand River watershed, low to high intensity development comprises approximately 1.81 percent and open space comprises approximately 2.40 percent. Degradation of water quality associated with imperviousness has been shown to first occur in a watershed at about 10 percent total imperviousness and to increase in severity as imperviousness increases (Arnold and Gibbons 1996; Schueler 1994). Due to the small amount of development in the watershed, runoff from developed areas is not expected to contribute substantial amounts of *E. coli* to the impaired water bodies. If the developed areas are expanded in the future, BMPs and low impact development should be considered to mitigate pollutant loading from impervious surfaces.

5.2.3 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems treat and disperse domestic wastewater on the property where it is generated. When properly designed and maintained, these systems perform well and should not contribute substantial amounts of *E. coli* to surface waters. However, when these systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration) there can be adverse effects to surface water quality (Horsley and Witten 1996). The Missouri Department of Health and Senior Services or local administrative authorities (commonly the local health department) have jurisdiction over onsite wastewater treatment systems with a design or actual flow of 3,000 gallons per day or less. Municipalities or counties may impose more stringent or additional requirements for owners of onsite wastewater treatment systems. The Missouri Department of Health and Senior Services estimates that approximately 25 percent of homes in Missouri use onsite wastewater treatment systems, particularly in rural areas where public sewer systems are not available (DHSS 2018). Failing onsite wastewater treatment systems can contribute *E. coli* to nearby streams under wet or dry weather conditions directly or through surface runoff and groundwater flows. Factors that may contribute to onsite wastewater treatment system failure include age, inadequate land area, poor soil drainage, high water table, and inadequate maintenance. Proper maintenance of onsite wastewater treatment systems including septic tanks, associated drain fields, and household lagoons should minimize bacteria loading to surface waters.

The exact number of onsite wastewater treatment systems in the Grand River watershed is unknown. EPA's online input data server for the Spreadsheet Tool for Estimating Pollutant Load (STEPL) provides estimates of septic system numbers by 12-digit HUC watersheds based on 1992 and 1998 data from the National Environmental Service Center (USEPA 2014b).²¹ These STEPL

²¹ The National Environmental Services Center is located at West Virginia University and maintains a clearinghouse for information related to, among other things, onsite wastewater treatment systems. Available URL: www.nesc.wvu.edu/

derived estimates of septic system numbers are provided in Table 11. Due to the numerous 12-digit HUC watersheds in the Grand River catchment, Table 11 provides mean 8-digit HUC watershed septic data generated from 12-digit HUC STEPL data. There are approximately 4,687 septic sewer systems in the entire watershed and 1,446 in the Missouri side of the watershed. Although there has been a slight decrease in population since the 1990 census, this data is assumed to provide a reasonable estimate of actual septic system numbers.

A study by the Electric Power Research Institute suggests that in parts of Missouri, up to 50 percent of onsite wastewater treatment systems may be failing (EPRI 2000). Due to this high failure rate, onsite wastewater treatment systems are potential sources of bacteria loading to surface waters in Missouri. However, at the time of this writing, the significance of such contributions to the *E. coli* impairments in the Grand River watershed is unknown. The greater the distance an onsite system is located from a surface water, the less likely it is to cause contamination (MU Extension 2023).

Table 11. STEPL derived estimates of septic system numbers for HUC 8-digit watersheds

HUC 8 Watershed Name	HUC8 #	Number of HUC 12s in HUC 8	Mean # of Septic Systems per HUC 12	Population per Septic System
Thompson River	10280102	61	88	2
Lower Missouri-Crooked	10300101	74	434	2
Lower Chariton	10280202	29	108	2
Nodaway	10240010	28	84	2
Platte	10240012	51	157	2
Upper Grand	10280101	101	108	2
Lower Grand	10280103	64	82	2
Upper Chariton	10280201	38	113	2

5.2.4 Natural Background Contributions

Wildlife such as deer, waterfowl, raccoons, rodents, and other animals contribute to the natural background concentrations of *E. coli* that may be found in a water body. Such contributions may be a component of runoff from agricultural areas, developed areas, forest lands, and other areas. While typical wildlife populations are not expected to cause or contribute to water body impairments, animals that congregate in large groups on or near water bodies may contribute significant bacteria to surface waters. For instance, Canada geese have been found to contribute significant bacteria loads in some waters (Ishii et al. 2007). There are no watershed-specific population data for Canada geese or other waterfowl, but the Missouri Department of Conservation conducts statewide surveys in fall and winter. In 2020, waterfowl counts ranged from approximately 59,000 in October to 760,000 in late November (MDC 2021). The exact number of deer in the watershed is also not known, but the Missouri Department of Conservation keeps harvest records by county for each hunting season. Harvest data provides a general idea of the amount of deer that may be present in an area. Table 12 presents yearly harvest for 2021-2022 whitetail deer hunting season for the counties found in the Grand River watershed (MDC 2023). Background concentrations of bacteria may also be present in benthic sediments and, if disturbed, can be resuspended as bacteria lives longer in sediment than in water (Davis and Barr 2006; Marino and Gannon 1991). The significance of any resuspended bacteria to the impairment in Grand River watershed is unknown. Natural background contributions are included in the nonpoint source load allocation.

Table 12. 2021-2022 white tailed deer harvest for counties in the Grand River watershed

County	Worth	Gentry	DeKalb	Clinton	Harrison
Deer Harvest counts	1,170	1,611	988	880	3,413
County	Daviess	Caldwell	Ray	Mercer	Grundy
Deer Harvest counts	2,711	1,724	1,556	2,093	1,879
County	Livingston	Carroll	Putman	Sullivan	Linn
Deer Harvest counts	1,977	2,402	2,602	2,485	2,870
County	Chariton	Nodaway	Andrew		
Deer Harvest counts	2,027	1,675	1,154		

5.2.5 Riparian Corridor Conditions

Riparian corridor conditions have a strong influence on instream water quality. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the attenuation of pollutants in runoff. Land cover within 100 feet of streams in the Grand River watershed are presented in Table 13. Agricultural areas constitute approximately 40 percent of the riparian corridors of streams in the Grand River watershed. These areas may be more susceptible to *E. coli* loading. Approximately a half percent of the riparian corridors are forested. This indicates that some *E. coli* transported from nearby cropland and pasture lands into those areas may be intercepted by forested lands before it enters the streams.

Table 13. Land cover in riparian corridors in the Grand River watershed

Land Cover Type	Total Watershed		Missouri Only	
	Square Miles	Percent	Square Miles	Percent
Developed, High Intensity	0.04	0.01%	0.05	0.01%
Developed, Medium Intensity	0.44	0.11%	0.48	0.12%
Developed, Low Intensity	3.13	0.78%	3.00	0.77%
Developed, Open Space	5.04	1.25%	6.20	1.58%
Barren Land	0.53	0.13%	0.70	0.18%
Cultivated Crops	67.39	16.73%	54.09	13.80%
Grassland and Pasture	94.80	23.54%	85.45	21.80%
Scrub and Herbaceous	148.42	36.85%	161.41	41.19%
Forest	2.24	0.56%	2.19	0.56%
Wetlands	67.70	16.81%	65.09	16.61%
Open Water	13.02	3.23%	13.24	3.38%
Total	402.74	100.00%	391.89	100.00%

6. Calculating Loading Capacity

A TMDL is equal to the loading capacity of a water body for a specific pollutant, which is the maximum pollutant load that a water body can assimilate and still attain and maintain water quality standards. The loading capacity is derived from the numeric water quality criterion for each pollutant or an appropriate surrogate when no numeric criterion is applicable. Once the maximum allowable pollutant load is determined, a portion is assigned to point sources as a wasteload allocation and to nonpoint sources as a load allocation. These allocations become the pollutant

loading targets to restore water quality. A margin of safety is included to account for uncertainties in scientific and technical understanding of water quality in natural systems and to ensure water quality standards are achieved after all wasteload and load allocations are met.²² The loading capacity is equal to the sum of the wasteload allocation, load allocation, and the margin of safety as follows:

$$\text{TMDL} = \text{LC} = \sum \text{WLA} + \sum \text{LA} + \text{MOS}$$

where LC is the loading capacity, $\sum \text{WLA}$ is the sum of the wasteload allocations, $\sum \text{LA}$ is the sum of the load allocations, and MOS is the margin of safety.

7. Total Maximum Daily Loads

According to 40 CFR 130.2(i), TMDLs can be expressed in terms of mass per unit time, toxicity, or other appropriate measures. The TMDLs for the Grand River watershed are expressed as *E. coli* cfu per day using a load duration curve developed using the *E. coli* criterion concentration of 126 cfu/100 mL, all possible stream flows, and a unit conversion factor.²³ Whole body contact A use criteria, the most stringent downstream criteria, was targeted for all Grand River streams, which in some cases provides additional protections beyond a given waterbodies less protective assigned criteria. Establishing TMDLs using load duration curves is consistent with the Anacostia Ruling (*Friends of the Earth, Inc., et al v. EPA*, No 05-5010, April 25, 2006) and EPA guidance in response to that ruling (USEPA 2006; USEPA 2007a).

The selected TMDL targets are protective of whole body and secondary contact recreational uses. The resulting load duration curves provide a visual representation of the pollutant loading capacity of each stream at all flows. The TMDL is applicable during the recreational season when the *E. coli* criteria apply. Using this approach, the available loading capacity of a stream varies with flow, but the pollutant concentration remains constant. Although TMDLs are expressed as daily mass loads, *E. coli* criteria are expressed as geometric mean concentrations. Therefore, fluctuations in instantaneous concentrations are expected and individual bacteria measurements greater than the applicable criterion do not necessarily indicate a violation of water quality standards. Additional discussion about the methods used to develop the load duration curves for streams in the Grand River watershed are provided in Appendix B.

Observed *E. coli* data are plotted on the load duration curve graphs to illustrate the frequency of exceedance and the magnitude of load reductions needed to meet the TMDL. Points above the curve exceed the loading capacity and points on or below the curve are in compliance with water quality standards. The load duration curve also helps to identify and differentiate between storm-driven loading and the presence of continuous loading. Storm-driven loading is expected under wet conditions when precipitation and runoff are high. Continuous loading is evident at low flows when point source discharges have greater influence on water quality. Load reductions needed to meet the *E. coli* criterion can be estimated using the geometric means of observed data within each flow percentile range and are provided in the supplemental Implementation Strategies document located at: <https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls>.

²² CWA Section 303(d)(l)(C) and 40 CFR 130.7(c)(l) require TMDLs to incorporate a margin of safety.

²³ $\text{Load} \left(\frac{\text{count}}{\text{time}} \right) = \text{Concentration} \left(\frac{\text{count}}{\text{volume}} \right) * \text{Flow} \left(\frac{\text{volume}}{\text{time}} \right) * \text{conversion factor} (24,465,715)$

The *E. coli* load duration curves for the streams in the Grand River watershed are displayed in Figures 12 through 17. The y-axis quantifies the *E. coli* mass load in cfu per day at the flow conditions (percentage of time flow is equaled or exceeded) on the x-axis. Lower flows are equaled or exceeded more frequently than higher flows (i.e., greater than 90 percent of the time). The flow ranges presented are consistent with EPA guidance for using load duration curves to develop TMDLs (USEPA 2007b).

The loading capacity for each stream is calculated using both the applicable 126 cfu/100mL criterion concentration in Missouri and the applicable 126 cfu/100mL criterion concentration in Iowa based on the proportion of flow originating from each state.²⁴ A target concentration of 126 cfu/100 mL is applied to the entirety of the East Fork Locust Creek due to the Whole Body Contact Recreation category A use designation for a portion of the stream (WBID 610). Tables 14 through 23 display specific loading capacities and allocations for the total watershed and Missouri side of the watershed where applicable. Due to the extremely large numbers associated with bacteria loads, *E. coli* values are presented using scientific notation. Loading values presented in Tables 14 through 23 accurately reflect calculations based on the applicable criteria concentrations, which results in bacteria loads of billions or trillions counts per day. However, due to rounding and the limited number of decimal places displayed, summation of the allocation values displayed may not exactly match the presented load capacity in all cases. Specific allocations for individual sources are discussed in Sections 8 and 9.

²⁴ The State of Iowa Water Quality Standards (WQS) are published in the Iowa Administrative Code (IAC), Environmental Protection Rule 567, Chapter 61. In Iowa, the streams designated uses are class A1 for Primary Contact Recreational Use. For more information on Iowa's designated uses see 567.61.3(1). Under subrule 61.3(3), Class A1 Rivers' *E. coli* concentrations during the recreational season (3/15-11/15) shall not exceed the geometric mean of 126 cfu/100 mL.

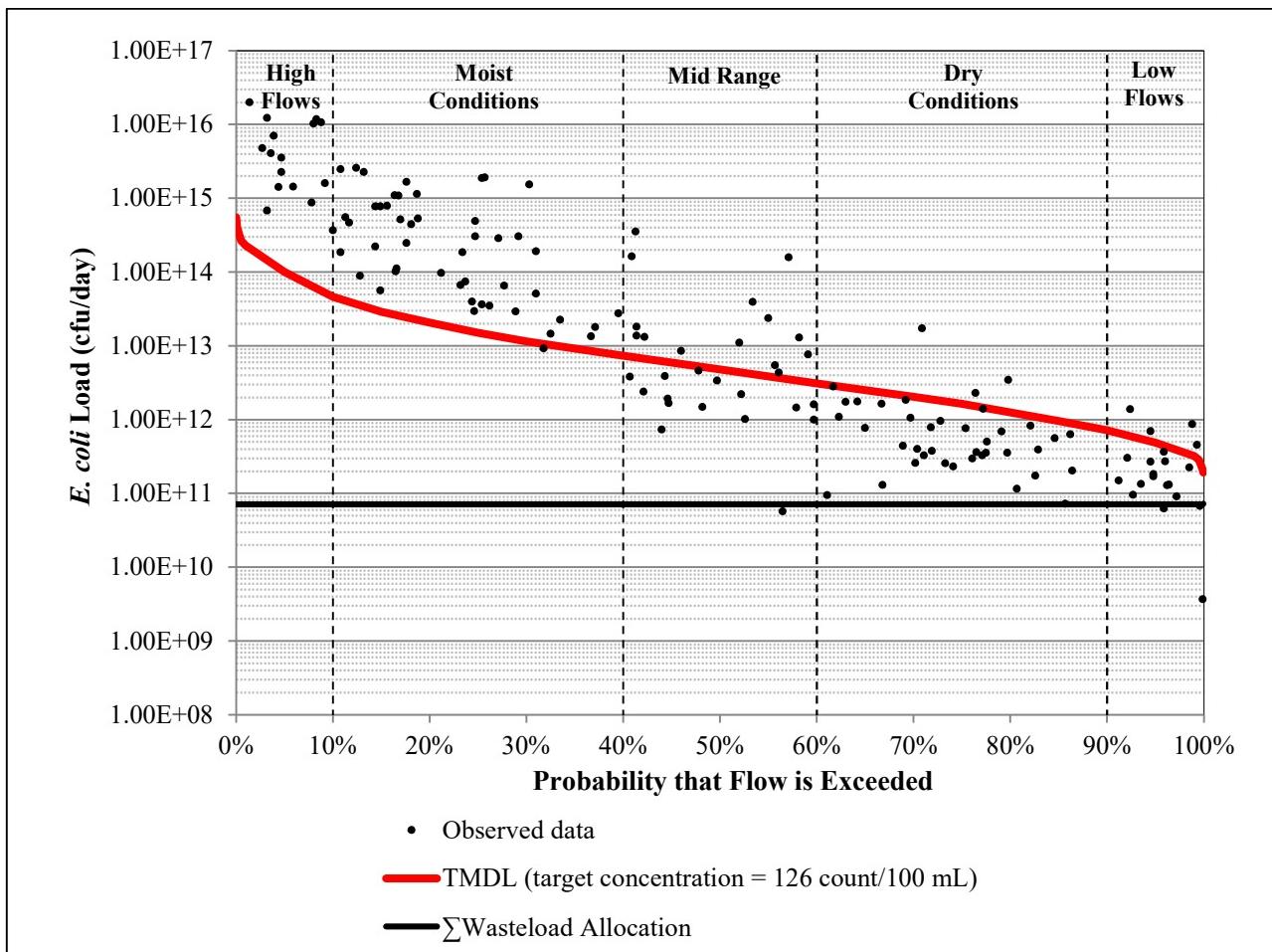


Figure 12. *E. coli* TMDL for the Grand River (WBID 593)

Table 14. *E. coli* TMDL and allocations for the Grand River (WBID 593) at selected flows

Percent of time flow is equaled or exceeded	Flow (ft ³ /s)	LC (counts/day)	ΣWLA (counts/day)	MO ΣLA (counts/day)	IA ΣLA (counts/day)	Explicit MOS (counts/day)
95	159	4.89E+11	7.09E+10	2.88E+11	8.12E+10	4.89E+10
75	531	1.64E+12	7.09E+10	1.09E+12	3.08E+11	1.64E+11
50	1,553	4.79E+12	7.09E+10	3.31E+12	9.31E+11	4.79E+11
25	4,865	1.50E+13	7.09E+10	1.05E+13	2.95E+12	1.50E+12
5	32,545	1.00E+14	7.09E+10	7.04E+13	1.98E+13	1.00E+13

Table 15. *E. coli* TMDL and allocations for the Missouri portion of the Grand River (WBID 593) at selected flows

Percent of time flow is equaled or exceeded	Flow (ft ³ /s)	LC (counts/day)	Σ WLA (counts/day)	Σ LA (counts/day)	Explicit MOS (counts/day)
95	124	3.82E+11	7.09E+10	2.73E+11	3.82E+10
75	414	1.28E+12	7.09E+10	1.08E+12	1.28E+11
50	1,211	3.73E+12	7.09E+10	3.29E+12	3.73E+11
25	3,794	1.17E+13	7.09E+10	1.05E+13	1.17E+12
5	25,385	7.83E+13	7.09E+10	7.04E+13	7.83E+12

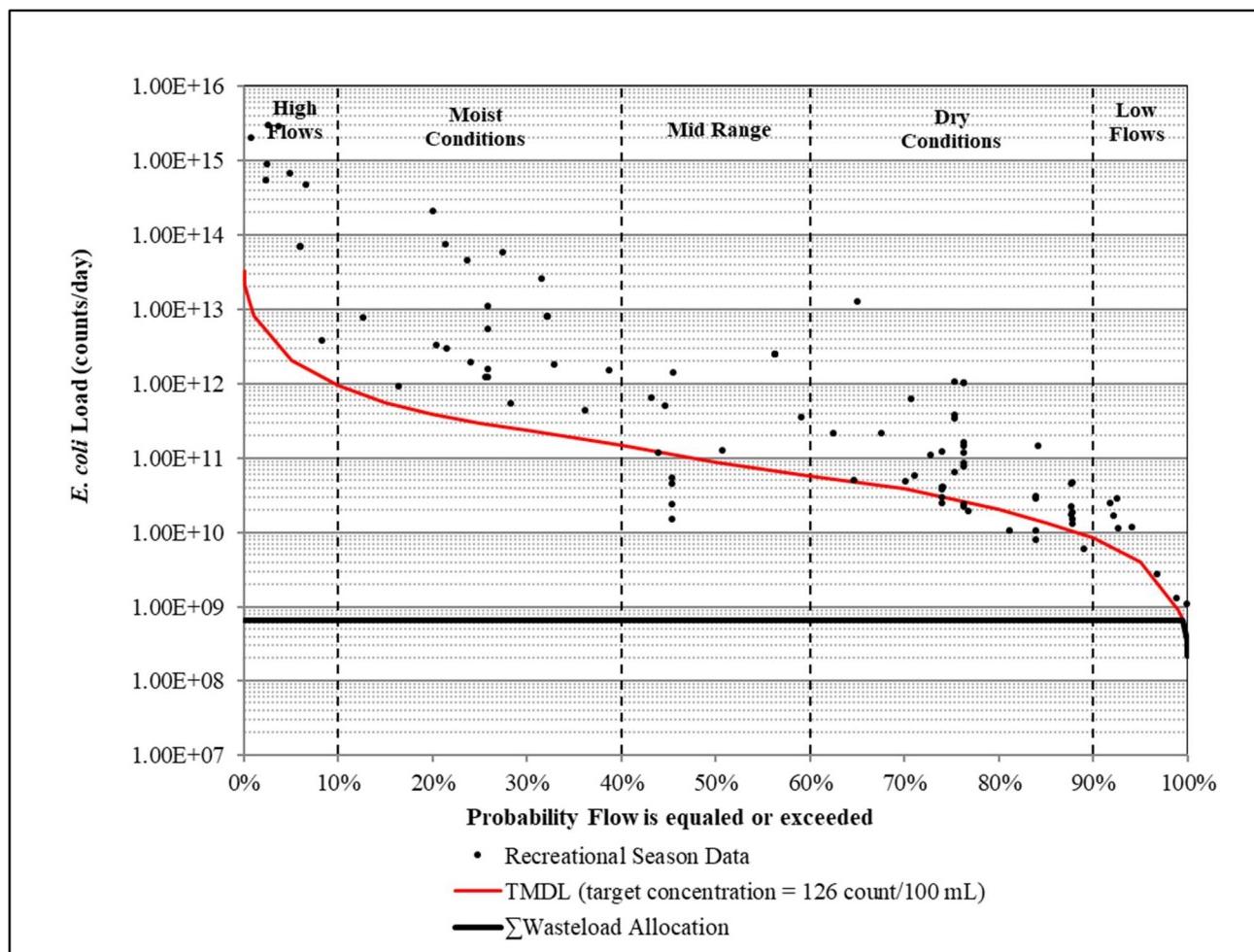
**Figure 13. *E. coli* TMDL for the Middle Fork Grand River (WBID 468)**

Table 16. *E. coli* TMDL and allocations for Middle Fork Grand River (WBID 468) at selected flows

Percent of time flow is equaled or exceeded	Flow (ft ³ /s)	LC (counts/day)	\sum WLA (counts/day)	MO \sum LA (counts/day)	IA \sum LA (counts/day)	Explicit MOS (counts/day)
95	1.32	4.08E+09	6.68E+08	2.34E+09	6.60E+08	4.08E+08
75	9.26	2.85E+10	6.68E+08	1.95E+10	5.50E+09	2.85E+09
50	28.62	8.82E+10	6.68E+08	6.14E+10	1.73E+10	8.82E+09
25	95.06	2.93E+11	6.68E+08	2.05E+11	5.78E+10	2.93E+10
5	676.20	2.08E+12	6.68E+08	1.46E+12	4.12E+11	2.08E+11

Table 17. *E. coli* TMDL and allocations for Missouri portion of the Middle Fork Grand River (WBID 468) at selected flows

Percent of time flow is equaled or exceeded	Flow (ft ³ /s)	LC (counts/day)	\sum WLA (counts/day)	\sum LA (counts/day)	Explicit MOS (counts/day)
95	0.94	2.90E+09	6.68E+08	1.94E+09	2.90E+08
75	6.58	2.03E+10	6.68E+08	1.76E+10	2.03E+09
50	20.32	6.26E+10	6.68E+08	5.57E+10	6.26E+09
25	67.49	2.08E+11	6.68E+08	1.87E+11	2.08E+10
5	480.10	1.48E+12	6.68E+08	1.33E+12	1.48E+11

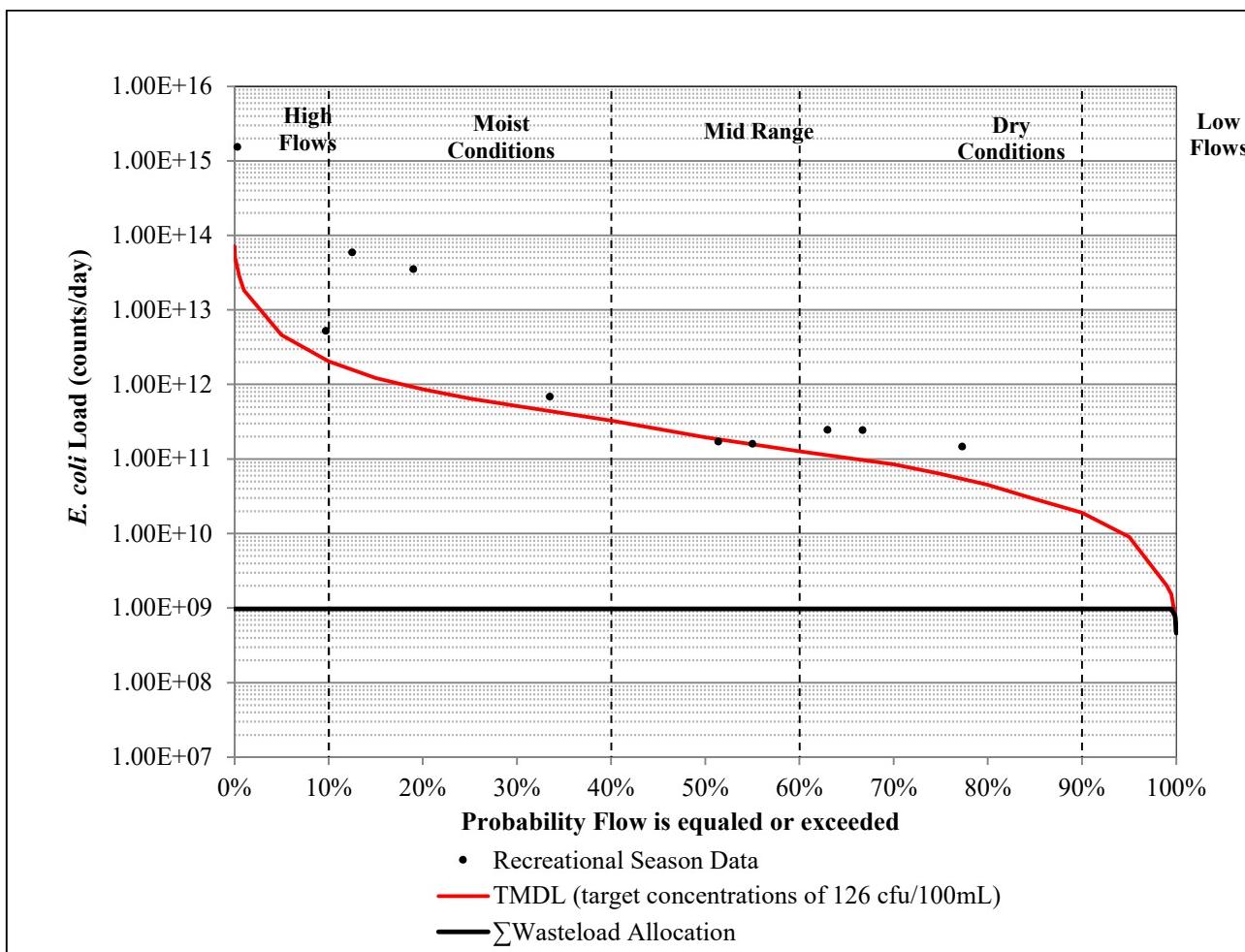


Figure 14. *E. coli* TMDL for the East Fork Grand River (WBID 457)

Table 18 *E. coli* TMDL and allocations for the East Fork Grand River (WBID 457) at selected flows

Percent of time flow is equaled or exceeded	Flow (ft ³ /s)	LC (counts/day)	Σ WLA (counts/day)	MO Σ LA (counts/day)	IA Σ LA (counts/day)	Explicit MOS (counts/day)
95	2.92	8.99E+09	9.78E+08	5.55E+09	1.56E+09	8.99E+08
75	20.41	6.29E+10	9.78E+08	4.34E+10	1.22E+10	6.29E+09
50	63.07	1.94E+11	9.78E+08	1.36E+11	3.82E+10	1.94E+10
25	209.52	6.46E+11	9.78E+08	4.53E+11	1.28E+11	6.46E+10
5	1,490.40	4.59E+12	9.78E+08	3.23E+12	9.08E+11	4.59E+11

Table 19. *E. coli* TMDL and allocations for Missouri portion of the East Fork Grand River (WBID 457) at selected flows

Percent of time flow is equaled or exceeded	Flow (ft ³ /s)	LC (counts/day)	Σ WLA (counts/day)	Σ LA (counts/day)	Explicit MOS (counts/day)
95	1.78	5.48E+09	2.35E+09	2.59E+09	5.48E+08
75	12.45	3.84E+10	2.35E+09	3.22E+10	3.84E+09
50	38.47	1.19E+11	2.35E+09	1.04E+11	1.19E+10
25	127.81	3.94E+11	2.35E+09	3.52E+11	3.94E+10
5	909.14	2.80E+12	2.35E+09	2.52E+12	2.80E+11

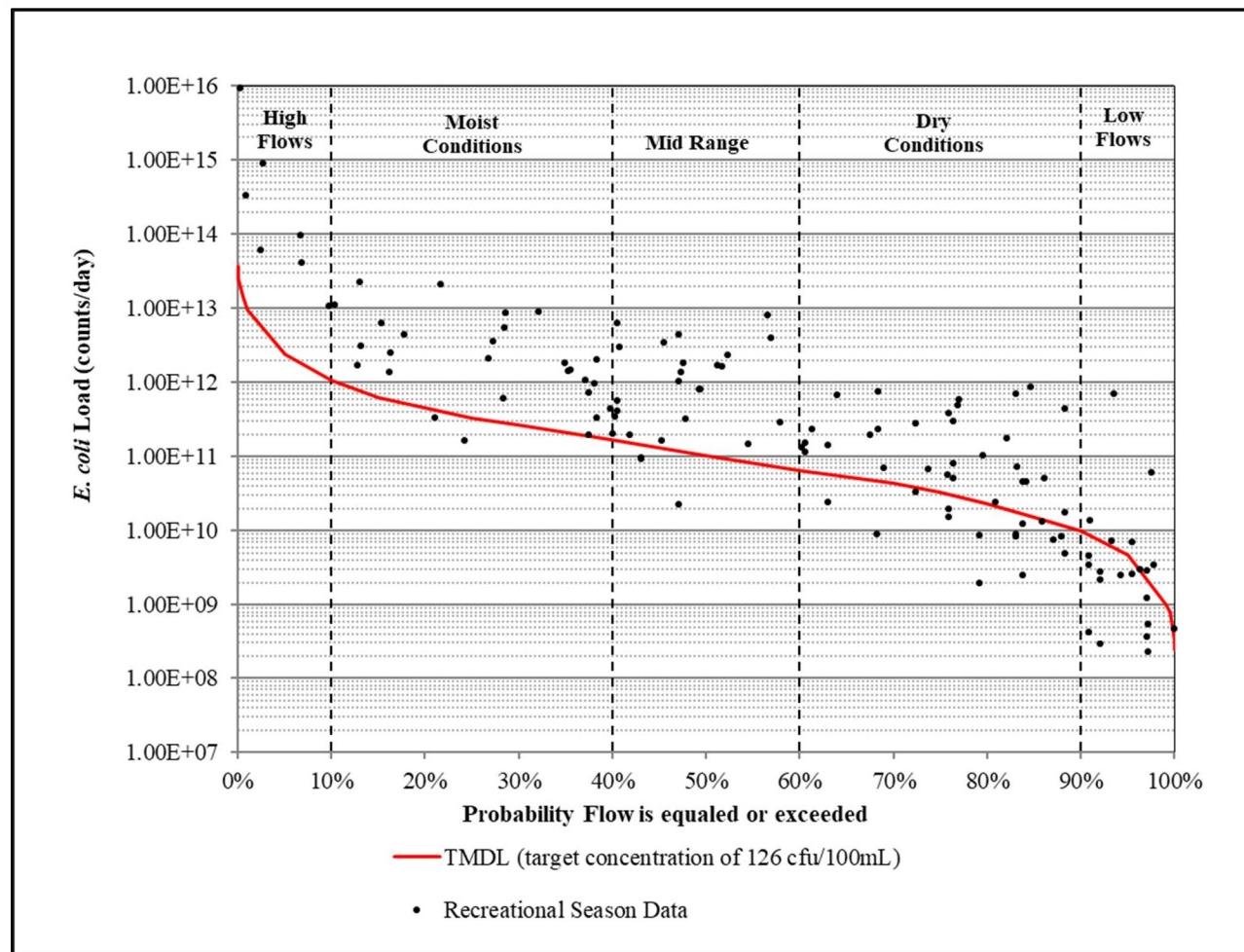
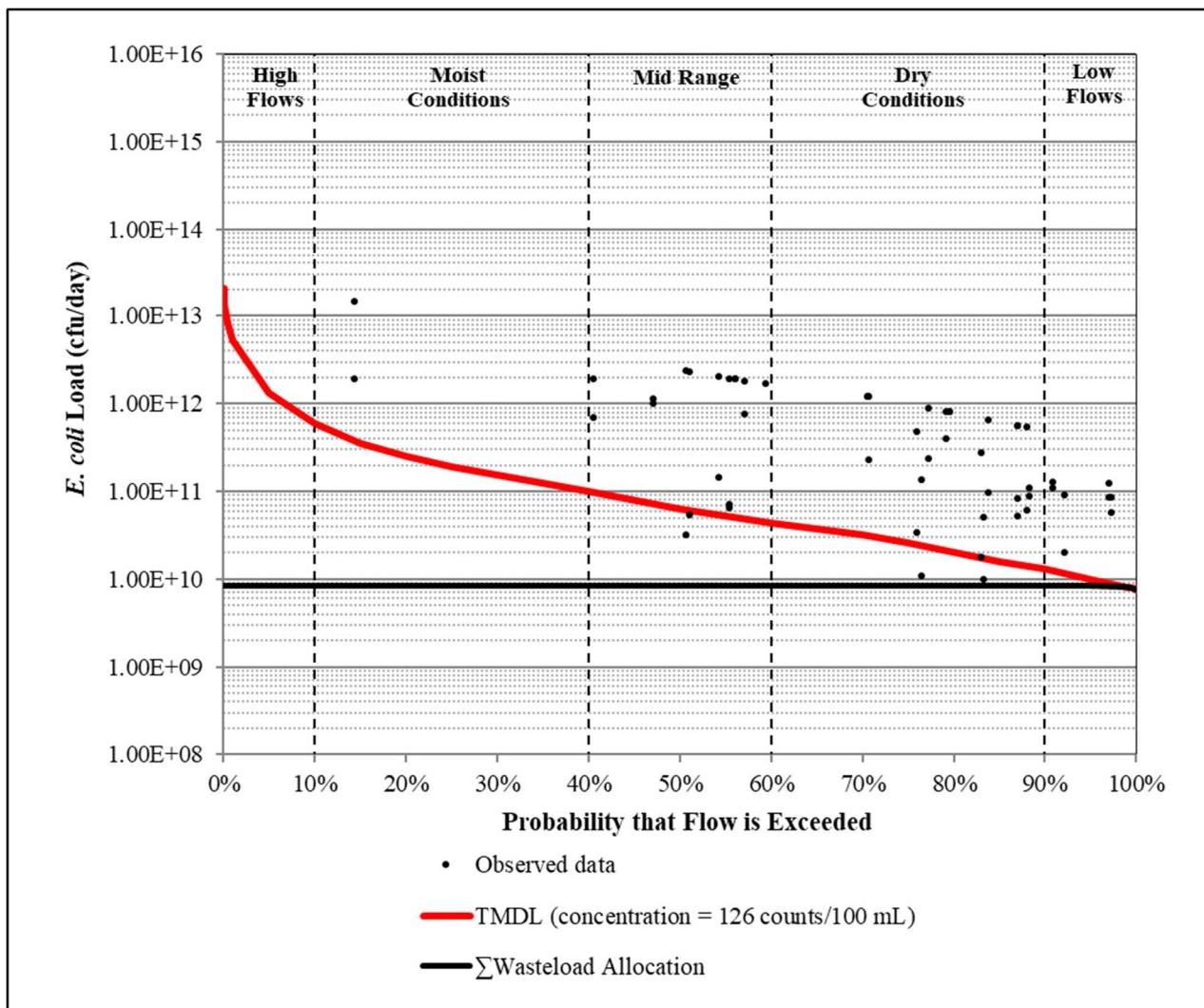
**Figure 15. *E. coli* TMDL for Locust Creek (WBID 606)**

Table 20. *E. coli* TMDL and allocations for Locust Creek (WBID 606) at selected flows

Percent of time flow is equaled or exceeded	Flow (ft ³ /s)	LC (counts/day)	Σ WLA (counts/day)	MO Σ LA (counts/day)	IA Σ LA (counts/day)	Explicit MOS (counts/day)
95	1.51	4.66E+09	0.00E+00	3.27E+09	9.23E+08	4.66E+08
75	10.58	3.26E+10	0.00E+00	2.29E+10	6.46E+09	3.26E+09
50	32.70	1.01E+11	0.00E+00	7.08E+10	2.00E+10	1.01E+10
25	108.64	3.35E+11	0.00E+00	2.35E+11	6.63E+10	3.35E+10
5	772.80	2.38E+12	0.00E+00	1.67E+12	4.72E+11	2.38E+11

Table 21. *E. coli* TMDL and allocations for Missouri portion of the Locust Creek (WBID 606) at selected flows

Percent of time flow is equaled or exceeded	Flow (ft ³ /s)	LC (counts/day)	Σ WLA (counts/day)	Σ LA (counts/day)	Explicit MOS (counts/day)
95	1.18	3.64E+09	0.00E+00	3.27E+09	3.64E+08
75	8.26	2.54E+10	0.00E+00	2.29E+10	2.54E+09
50	25.51	7.86E+10	0.00E+00	7.08E+10	7.86E+09
25	84.74	2.61E+11	0.00E+00	2.35E+11	2.61E+10
5	602.78	1.86E+12	0.00E+00	1.67E+12	1.86E+11

**Figure 16.** *E. coli* TMDL for East Fork Locust Creek (WBID 608)**Table 22.** *E. coli* TMDL and allocations for East Fork Locust Creek (WBID 608) at selected flows

Percent of time flow is equaled or exceeded	Flow (ft ³ /s)	LC (counts/day)	Σ WLA (counts/day)	MO Σ LA (counts/day)	Explicit MOS (counts/day)
95	3.27	1.01E+10	8.35E+09	0.00E+00	1.01E+09
75	8.30	2.56E+10	8.49E+09	1.45E+10	2.56E+09
50	20.54	6.33E+10	8.49E+09	4.85E+10	6.33E+09
25	62.58	1.93E+11	8.49E+09	1.65E+11	1.93E+10
5	430.24	1.33E+12	8.49E+09	1.19E+12	1.33E+11

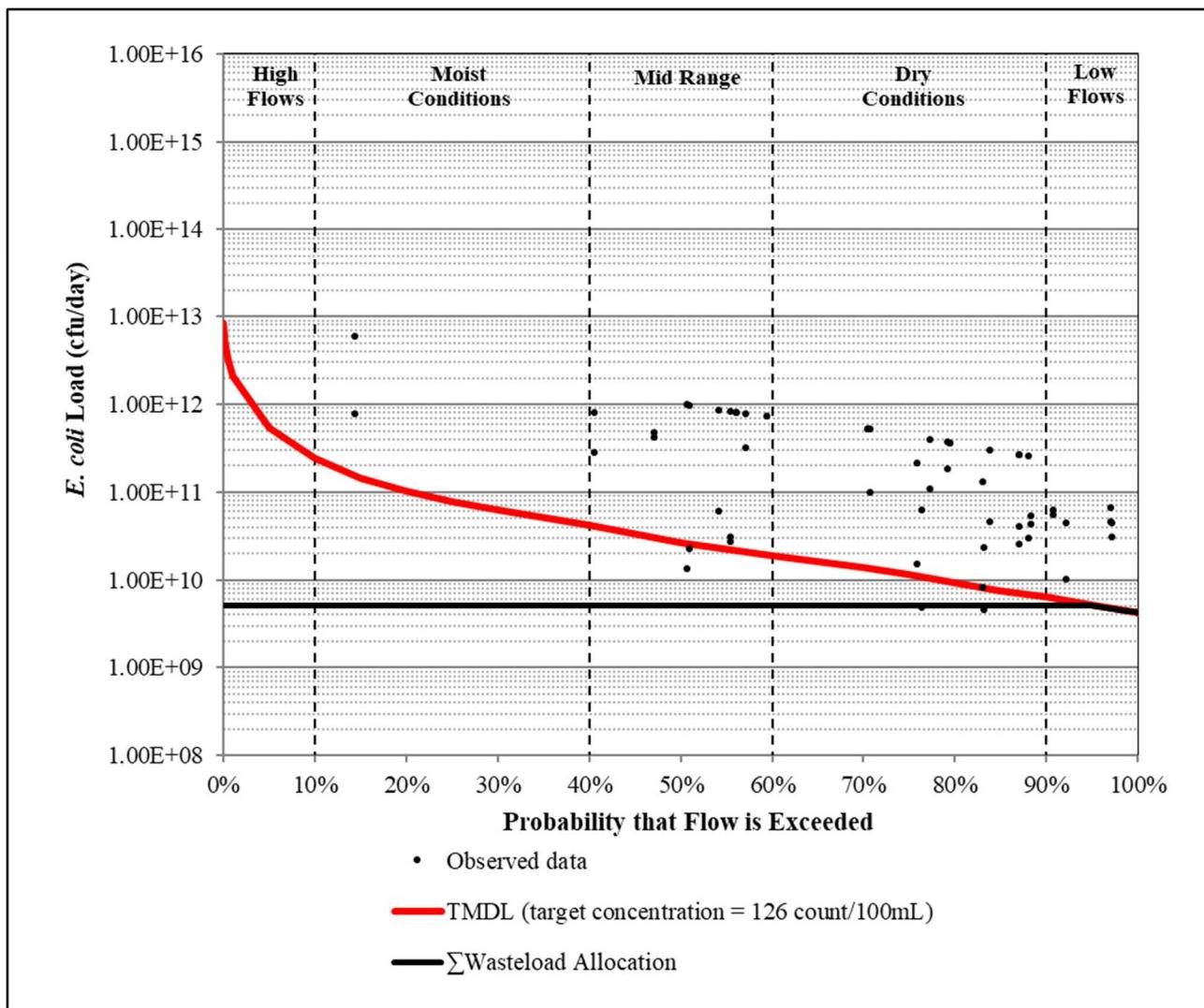


Figure 17. *E. coli* TMDL for East Fork Locust Creek (WBID 610)

Table 23. *E. coli* TMDL and allocations for East Fork Locust Creek (WBID 610) at selected flows

Percent of time flow is equaled or exceeded	Flow (ft ³ /s)	LC (counts/day)	\sum WLA (counts/day)	\sum LA (counts/day)	Explicit MOS (counts/day)
95	1.69	5.21E+09	5.15E+09	0.00E+00	0.00E+00
75	3.71	1.14E+10	5.15E+09	5.14E+09	1.14E+09
50	8.64	2.66E+10	5.15E+09	1.88E+10	2.66E+09
25	25.54	7.87E+10	5.15E+09	6.57E+10	7.87E+09
5	173.42	5.35E+11	5.15E+09	4.76E+11	5.35E+10

8. Wasteload Allocation (Point Source Load)

The wasteload allocation is the portion of the loading capacity assigned to existing or future point sources. Pursuant to 40 CFR 122.44(d)(1)(vii)(B), effluent limits or other permit conditions must be consistent with the assumptions and requirements of TMDL wasteload allocations. Missouri cannot impose TMDL wasteload allocations onto another state, therefore, wasteload allocation targets are calculated only for Missouri permitted facilities. In order to achieve Missouri water quality standards through the loading targets established by this TMDL, it must be assumed that any point source pollutant contributions from Iowa will be limited to ensure Missouri's water quality standards will be met at the state line. The Iowa *E. coli* criterion concentration for the Grand River watershed streams is 126 cfu/100mL and is more stringent than the Missouri Whole Body Contact B criterion concentration of 206 cfu/100 mL.

The wasteload allocations presented in this TMDL report do not preclude the establishment of future point sources. Any future point sources should be evaluated against the TMDL, the range of flows with which any additional bacterial loading will affect, and any additional requirements associated with antidegradation. Federal regulation 40 CFR 122.4(a), disallows the issuance of a NPDES permit if the conditions of the permit cannot provide for compliance with the applicable requirements of the federal Clean Water Act, or regulations promulgated under the federal Clean Water Act. Additionally, 40 CFR 122.4(i) states no permit may be issued to a new source or new discharger if the discharge from its construction or operation will cause or contribute to violation of water quality standards. After undergoing antidegradation review, any new facility that discharges wastewater containing *E. coli* should operate in a manner that will not result in loading greater than the established wasteload allocation. New facilities that generate *E. coli* but disinfect wastewater prior to discharge or implement other appropriate measures to eliminate *E. coli* from effluent during the recreational season (e.g., no discharge or batch discharge) will result in negligible bacteria loading and will be consistent with the assumptions and requirements of the established wasteload allocation. Decommissioning of onsite wastewater treatment systems and connecting to sewerage systems for wastewater treatment will result in net pollutant reductions that are consistent with the goals of this TMDL. Due to localized health concerns associated with bacteria and whole body contact recreation, water quality trading cannot be used as a mechanism for complying with the wasteload allocations established by this TMDL.

8.1 Domestic Wastewater Treatment Facilities

Allocations are based on individual facility design flows and the appropriate whole body contact *E. coli* criterion concentration of 126 cfu/100 mL (Tables 24 through 27). Actual flows that are less than the design flows may result in bacteria loads less than the calculated wasteload allocations. The wasteload allocations in this TMDL report do not authorize any facility to discharge bacteria at concentrations that exceed water quality standards, but may accommodate additional facility loading due to population increases or expansions in service area. Wasteload allocations are assigned for each impaired stream where point sources are present, however the allocations are not additive. The wasteload allocations in this TMDL report are applicable at all flows during the recreational season and do not include loading that may result from sanitary sewer overflows. Sanitary sewer overflows are unpermitted discharges and not authorized under the Clean Water Act. For this reason, sanitary sewer overflows in the Grand River watershed are assigned wasteload allocations of zero at all flows.

Table 24. Wasteload allocations for domestic wastewater discharges in the Grand River (WBID 593)

Permit Number	Facility Name	E. coli Target Concentration (cfu/100 mL)	WLA (cfu/day)
MO0039748	Trenton Municipal Utilities WWTP		1.43E+10
MO0108227	Chillicothe WWTP		1.43E+10
MO0104299	Cameron WWTP		7.63E+09
MO0137553	Brookfield WWTP		4.77E+09
MO0033502	Bethany WWTF		2.40E+09
MO0039721	Marceline WWTP		2.15E+09
MO0027812	Gallatin WWTP		1.43E+09
MO0112704	Lathrop WWTF		1.10E+09
MO0028762	Princeton WWTF		9.11E+08
MO0043231	Stanberry WWTF		8.92E+08
MO0041106	Maysville WWTF		7.63E+08
MO0028061	Braymer WWTF		6.92E+08
MO0129216	Twin Lakes WWTF		6.68E+08
MO0022080	Hamilton NE WWTF		6.20E+08
MO0032557	Brunswick WWTF		4.96E+08
MO0093891	Breckenridge WWTF		3.82E+08
MO0022071	Hamilton SE WWTF		3.48E+08
MO0100382	Pattonsburg WWTP		3.41E+08
MO0102709	Hale WWTF		2.97E+08
MO0048224	Ridgeway West WWTF		2.88E+08
MO0093491	Linneus WWTF		2.77E+08
MO0099856	Osborn WWTF		2.62E+08
MO0092932	Laclede WWTF		2.62E+08
MO0122467	Cainsville WWTF		2.41E+08
MO0051616	Browning WWTF		2.39E+08
MO0097608	Wheeling WWTF		2.38E+08
MO0111601	Altamont - Winston WWTF		2.34E+08
MO0056057	Mercer WWTF		2.29E+08
MO0135607	Bosworth WWTF		2.29E+08
MO0094692	Laredo WWTF		2.15E+08
MO0120405	Kingston WWTP		1.97E+08
MO0113930	Eagleville Wastewater Treatment Facility		1.91E+08
MO0095729	Galt WWTP		1.91E+08
MO0113026	Spickard WWTF		1.91E+08
MO0022063	Hamilton SW Municipal WWTF		1.76E+08
MO0125679	Utica WWTF		1.74E+08
MO0114685	New Hampton WWTF		1.70E+08
MO0087149	Jamesport WWTF		3.62E+08

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MO0091146	Chula WWTF		1.57E+08
MO0094714	Mendon WWTF		1.56E+08
MO0130052	Cowgill WWTP		1.43E+08
MO0118591	Kidder WWTF		1.26E+08
MO0117871	Newtown WWTF		1.23E+08
MO0125831	Purdin WWTF		1.22E+08
MO0125636	Parnell Lagoons WWTF		1.19E+08
MO0118010	Jameson WWTF		1.09E+08
MO0123081	Blythedale WWTF		1.07E+08
MO0130869	Ludlow WWTF		9.73E+07
MO0123960	Rockwood Creek Mobile Home Village WWTF		8.94E+07
MO0117862	Coffey WWTF		8.78E+07
MO0091600	Sumner WWTF		8.59E+07
MO0085910	Bucklin West WWTF		7.73E+07
MO0119750	Humphreys WWTF		6.34E+07
MO0132144	Elm Hills - Country Hills Estates WWTP		5.25E+07
MOG823074	Morrell Legacy Ranch WWTF		4.77E+07
MO0091570	Trexmart 16 WWTF		4.20E+07
MO0081345	SW Livingston Co R1 School District WWTP		3.82E+07
MO0048151	Milan WWTP		3.34E+09
MO0130281	Allendale WWTP		2.38E+07
MO0027600	Grant City West WWTF		6.68E+08
MO0021466	Albany WWTF		9.54E+08
MO0041114	Meadville		0.00E+00
MO0098663	Gilman City WWTF		0.00E+00
MO0099074	Linn Co. R-I School District WWTF		0.00E+00
MO0133663	MoDOT Visitor Welcome Center WWTF		0.00E+00
Total			7.09E+10

Table 25. Wasteload allocations for domestic wastewater discharges in the Middle Fork Grand River (WBID 468)

Permit Number	Facility Name	<i>E. coli</i> Target Concentration (cfu/100 mL)	WLA (cfu/ day)
MO0027600	Grant City West WWTF	126	6.68E+08

Table 26. Wasteload allocations for domestic wastewater discharges in the East Fork Grand River (WBID 457)

Permit Number	Facility Name	<i>E. coli</i> Target Concentration (cfu/100 mL)	WLA (cfu/ day)
MO0021466	Albany WWTF	126	9.54E+08
MO0130281	Allendale WWTP		2.38E+07
Total			9.78E+08

Table 27. Wasteload allocations for domestic wastewater discharges in the East Fork Locust Creek (WBID 608)

Permit Number	Facility Name	<i>E. coli</i> Target Concentration (cfu/100 mL)	WLA (cfu/ day)
MO0048151	Milan WWTP	126	3.34E+09

8.2 Industrial and Commercial Facilities

There is currently one site-specific permitted industrial facility located in greater Grand River watershed, Smithfield Fresh Meats, located in the East Fork Locust Creek (WBID 610) subwatershed. Table 28 provides the wasteload allocations for the Smithfield facility, which contributes flow and potential loading to three impaired stream segments. The assigned wasteload allocation is the same for each impaired water body and is included within the sum of the total wasteload allocation for each water body. As previously stated, although this facility is assigned an allocation for each impaired stream, these allocations are not additive.

Table 28. Wasteload allocations for industrial permitted facilities (WBID 610)

Permit Number	Facility Name	<i>E. coli</i> Target Concentration (cfu/100 mL)	WLA (cfu/ day)
MO0115487	Smithfield Fresh Meats	126	5.15E+09

8.3 Concentrated Animal Feeding Operations

All CAFO facilities in the Grand River watershed are subject to permit conditions that do not allow discharge directly or during land application. For this reason, the *E. coli* wasteload allocations for the CAFO facilities is zero at all flows. A wasteload allocation of zero is the most stringent allocation that can be assigned and indicates the need for 100 percent pollutant reduction from any contributing sources of this type.

8.4 Municipal Separate Storm Sewer Systems

There are no regulated MS4s in the Grand River watershed. *E. coli* in stormwater runoff from developed areas are included in the load allocation for nonpoint sources. If MS4 permits are required for stormwater discharges from urban areas in the future, then the appropriate proportion of the load allocation, as it relates to stormwater pollutant contributions, may be re-assigned as a wasteload allocation.

8.5 Other General Permitted Wastewater and Stormwater Discharges

There are ten facilities with an MOG22 in the Grand River Watershed that hold general permits that could potentially generate *E. coli*. These facilities are not authorized to discharge to surface waters and, as long as the requirements of the relevant subdivisions of the permits are met, will not contribute *E. coli* to the Grand River watershed. Because these facilities are prohibited from discharging to surface waters, the wasteload allocation for these ten facilities is zero at all flows.

Activities associated with other general or stormwater permits described in Section 5.1.5 are not typically expected to contribute *E. coli* to surface waters, and permit conditions are protective of the designated uses assigned to all water bodies in the watersheds. Activities for which these permits are issued are expected to be conducted in compliance with all permit conditions, including any land application, monitoring, stormwater pollution prevention plans, and discharge limitations. For

these reasons, the *E. coli* wasteload allocations for these facilities are set at current negligible loading based on existing permit limits and conditions. Future general and stormwater permitted activities that do not actively generate bacteria and that operate in full compliance with permit conditions are not expected to contribute bacteria loads above negligible levels and will not result in loading that exceeds the sum of the TMDL wasteload allocations.

8.6 Illicit Straight Pipe Discharges

Illicit straight pipe discharges are illegal and are not permitted under the federal Clean Water Act. For this reason, illicit straight pipe discharges are not allocated a portion of the available loading capacity and are assigned an *E. coli* wasteload allocation of zero. Any existing illicit straight pipe discharges must be eliminated and future discharges of this type should be prevented.

9. Load Allocation (Nonpoint Source Load)

The load allocation is the portion of the loading capacity assigned to existing and future nonpoint sources and natural background contributions (40 CFR 130.2(g)). The load allocation for this TMDL is calculated as the remainder of the loading capacity after allocations to the wasteload allocation and the margin of safety, as presented in Section 7. The load allocations include contributions from agricultural lands, runoff from developed areas, and natural background contributions. No portion of the load allocations is assigned to onsite wastewater treatment systems because when they are properly maintained and operating as designed, they do not discharge *E. coli* directly to surface waters. For this TMDL, the load allocation also includes any point source and nonpoint source contributions originating from Iowa. Based on Iowa's shared applicable criteria concentration of 126 cfu/100mL²⁵, it is assumed that point source contributions from Iowa will be limited to ensure Missouri water quality standards are met at the state line.

10. Margin of Safety

A margin of safety is required to account for uncertainties in scientific and technical understanding of water quality in natural systems (CWA Section 303(d)(l)(C) and 40 CFR 130.7(c)(l)). Based on EPA guidance (USEPA 2001), the margin of safety can be achieved through two approaches:

- Explicit - Reserve a portion of the loading capacity as a separate term in the TMDL.
- Implicit - Incorporate the margin of safety within the wasteload allocation and the load allocation calculations by making conservative assumptions in the analysis.

For this TMDL, both implicit and explicit margins of safety are used. Bacteria decay rates were not applied, and the direct recreational-season geometric mean concentration was applied as a target for estimating daily loading values as required by the federal Clean Water Act. Additionally, domestic wastewater treatment facilities employing disinfection technologies operate to eliminate nearly all present pathogens rather than targeting a specific water quality criterion (target = 0 cfu/day). This results in pollutant loading much lower than assigned wasteload allocations. These conservative assumptions serve as implicit margins of safety and are applicable during all flow conditions. Additionally, for water bodies designated for whole body contact recreation category B, TMDL targets are based on the more stringent criterion applicable for category A. This approach provides

²⁵ The State of Iowa Water Quality Standards (WQS) are published in the Iowa Administrative Cod (IAC), Environmental Protection Rule 567, Chapter 61. In Iowa, the stream's designated uses are class A1 for Primary Contact Recreational Use. For more information on Iowa's Designated uses see 567.61.3(1). Under subrule 61.3(3), Class A1 Rivers' *E. coli* concentrations during the recreational season (3/15-11/15) shall not exceed the geometric mean of 126 cfu/100mL.

added confidence that downstream waters, where the more stringent geomean criterion may apply, are protected, and, at the same time, requires additional pollutant reductions much greater than needed for attainment of the category B use. At flow conditions above extreme low flows where there is sufficient assimilative capacity, an explicit margin of safety equal to 10 percent of the loading capacity is applied in addition to the previously mentioned implicit margins of safety.

It should be noted that Missouri's recreational bacteria criteria, and targets used in this TMDL, do not differentiate between human and nonhuman sources of *E. coli*. Technical support materials published by EPA in 2024 and a quantitative microbial risk assessment published by EPA in 2010 note decreased risk of illness associated with recreational uses in waters where *E. coli* contamination occurs from nonhuman sources, such as livestock, manure, or wildlife (USEPA 2024 and USEPA 2010). In some instances, risks of illness from recreational exposure were described as being 20 to 30 times less in animal-impacted waters than human-impacted waters (USEPA 2010). Although conservative assumptions incorporated into water quality criteria are not implicit margins of safety as it pertains to TMDLs, such information lends support that TMDL targets will be greatly protective of recreational uses in largely forested or agriculturally dominated subwatersheds of the Grand River where human inputs are less likely or significantly less than animal sources.

Through the department's assessment methodologies and approach for development of this TMDL, effort was made to reduce overall uncertainty in the analyses. A majority of the *E. coli* samples collected over the last ten years were analyzed using an enzyme-specific media (Idexx/Colilert method). This method helps reduce variability, thus resulting in a more accurate and higher *E. coli* yield as compared to if conventional culture media are used. Additionally, when calculating the load duration curves and estimating individual stream flow duration, the department used verified measured flow data from USGS gage stations. Together these quality assured data were used to provide estimates of existing loading from which pollutant reduction targets can be derived.

Due to reduced uncertainty in the analysis and calculation of loading targets, along with the various implicit margins of safety outlined above, the department feels the approach used to calculate these TMDLs appropriately includes an adequate and sufficient margin of safety to fulfill the requirements of 40 CFR 130.7(c)(1). The use of an additional explicit margin of safety of 10 percent is intended to account for other unspecified and unquantified uncertainties or unknowns. Reserving a portion of the available loading capacity and not allocating it to either point or nonpoint sources only further ensures that water quality standards will be achieved when all wasteload and load allocations are achieved.

11. Seasonal Variation

Federal regulations at 40 CFR 130.7(c)(1) require that TMDLs take into consideration seasonal variation in applicable water quality standards. The load duration curves provide the *E. coli* loading capacities for each water body at all possible flow regimes using data collected during all seasons. The *E. coli* TMDLs are therefore protective of designated uses during critical conditions throughout the recreational season, including during high flows associated with intense rainfall events when bacteria loading is more likely.

12. Monitoring Plans

The department conducts water quality monitoring in impaired waters within a reasonable timeframe following the approval of TMDLs, completion of facility upgrades and permit

compliance schedules, or the implementation of watershed BMPs. The department will also routinely examine any available quality-assured water quality data collected by other local, state, and federal entities in order to assess the effectiveness of TMDL implementation. In addition, certain quality-assured data collected by universities, municipalities, private companies, and volunteer groups may be used to assess water quality following TMDL implementation.

13. Reasonable Assurance

Section 303(d)(1)(C) of the federal Clean Water Act requires that TMDLs be established at a level necessary to implement applicable water quality standards. As part of the TMDL process, consideration must be given to the assurances that point and nonpoint source allocations will be achieved and water quality standards attained. Where TMDLs are developed for waters impaired by point sources only, reasonable assurance is provided through the NPDES permitting program. State operating permits requiring effluent and instream monitoring be reported to the department provide reasonable assurance that instream water quality standards will be met.

Where a TMDL is developed for waters impaired by both point and nonpoint sources, point source wasteload allocations must be stringent enough so that in conjunction with the water body's other loadings (i.e., nonpoint sources) water quality standards are met. Reasonable assurance that nonpoint sources will meet their allocated amount is dependent upon the availability and implementation of nonpoint source pollutant reduction plans, controls, or BMPs within the watershed. If BMPs or other nonpoint source pollution controls allow for more stringent load allocations, then wasteload allocations can be less stringent. Thus, the TMDL process provides for nonpoint source control tradeoffs (40 CFR 130.2(i)). When a demonstration of nonpoint source reasonable assurance is developed for an impaired water body, additional pollutant allocations for point sources may be allowed provided water quality standards are still attained. If a demonstration of nonpoint source reasonable assurance does not exist, or it is determined that nonpoint source pollutant reduction plans, controls, or BMPs are not feasible, durable, or will not result in the required load reductions, then allocation of greater pollutant loading to point sources cannot occur.

A variety of grants and loans may be available to assist watershed stakeholders with developing and implementing watershed based plans, controls, and practices to meet the required wasteload and load allocations in the TMDL and demonstrate reasonable assurance. Information regarding potential funding sources, cost-share opportunities, and implementation actions that address nonpoint source loading in the Grand River watershed is provided in the supplemental TMDL Implementation Strategies document available online at: dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

14. Public Participation

EPA regulations at 40 CFR 130.7 require that TMDLs be subject to public review. An initial 45-day public notice period for this TMDL report was held from June 30, 2023, through August 14, 2023. Due to needed modifications to the underlying calculations of the loading capacity, the department updated the draft TMDL and scheduled a second 45-day public notice period, scheduled from January 5, 2024, through February 19, 2024. Groups that directly received notice of the public comment period include, but are not limited to:

- Missouri Clean Water Commission;
- Iowa Department of Natural Resources;
- Missouri Department of Conservation;

- Kansas City Regional Office;
- Mo-Kan Regional Planning Commission;
- Northwest Missouri Regional Planning Commission;
- Nodaway, Holt, and Andrew Soil and Water Conservation Districts;
- County health departments;
- County commissions;
- University of Missouri Extension;
- Missouri Coalition for the Environment;
- Missouri Farm Bureau;
- Stream Teams United;
- Stream Team volunteers living in or near the watershed; and
- Missouri state legislators representing areas within the watershed.

In addition to those groups directly contacted about the public notice, this TMDL report and an implementation strategies document are posted on the department's TMDL webpage at: dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdl. All comments received during this period and the department's responses to those comments will also be made available at this location for 30 days after submittal or until EPA approval, whichever is longer.

The department maintains an email distribution list for notifying subscribers of significant TMDL updates or activities, including public notices and comment periods. Those interested in subscribing to TMDL updates can submit their email address using the online form available at: public.govdelivery.com/accounts/MODNR/subscriber/new?topic_id=MODNR_177.

15. Administrative Record and Supporting Documentation

The department has an administrative record on file for the Grand River watershed *E. coli* TMDL. The record contains information on which the TMDL is based. It additionally includes the TMDL implementation strategies document, the public notice announcement, any public comments received, and the department's responses to those comments. This information is available upon request to the department at: dnr.mo.gov/open-records-sunshine-law-requests. The department will process any request for information about this TMDL in accordance with Missouri's Sunshine Law (Chapter 610, RSMo) and the department's administrative policies and procedures governing Sunshine Law requests.

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Appendix A

Table A1. Available *E. coli* Iowa assessment data for the Middle Fork Grand River impaired stream segments in Iowa.

Data Source	Data Source ID	# Samples / # Years	2011 Geometric Mean	Annual Geometric Mean Violation	# Violations	% Violations	Sig. > 10% Violations	Assessment Type
Iowa DNR	6	12/1	1,435	Yes	12	100%	Yes	Evaluated
	6	12/1	1,085	Yes	12	100%	Yes	Evaluated
	6	12/1	956	Yes	12	100%	Yes	Evaluated

Table A-2. Summary of available *E. coli* data for recreational season for the Grand River watershed impaired stream segments.

Waterbody (WBID)	Recreation Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean (cfu/100 mL)
Grand River (593)	2012	8	21	4,500	121
	2013	7	10	1,600	120
	2014	7	64	7,300	469
	2015	6	25	8,000	1,456
	2016	7	20	7,200	177
	2017	7	13	800	66
	2018	7	28	2,900	153
	2019	7	550	2,600	1,464
	2020	3	88	1,400	245
Waterbody (WBID)	Recreation Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean (cfu/100 mL)
Middle Fork Grand River (468)	2007	5	270	770	438
	2009	4	200	120,000	2,104
	2010	4	67	15,000	619
	2011	4	210	23,000	911
	2012	3	120	18,000	655
	2013	4	36	530	152
	2014	4	190	24,000	941
	2015	4	170	33,000	2,593
	2016	4	120	28,000	2,290
	2017	4	790	2,100	1,268
	2018	4	580	43,000	1,866
	2019	5	95	62,000	1,537
	2020	25	37	14,000	373
Waterbody (WBID)	Recreation Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean (cfu/100 mL)
East Fork Grand River (457)	2002	3	40	800	146
	2003	4	130	490	242
	2004	3	120	22,000	1,283
	2005	3	67	900	343
	2017	5	272	4,839	703
	2019	6	131	4,839	347

Waterbody (WBID)	Recreation Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean (cfu/100 mL)
Locust Creek (606)	2012	7	77	1,600	253
	2013	6	110	15,000	1,355
	2014	7	27	3,700	422.62
	2015	7	100	66,000	1,360
	2016	7	40	2,400	458
	2017	7	120	1,500	382
	2018	7	12	3,400	259.4
	2019	7	30	2,000	261
	2020	6	45	3,400	599
Waterbody (WBID)	Recreation Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean (cfu/100 mL)
East Fork Locust Creek (608)	2006	5	365	1,986	715
	2007	10	816	4,484	1,224
	2018	11	65	4,839	599
	2019	11	344	4,839	2,598
	2020	12	461	4,839	2,128
Waterbody (WBID)	Recreation Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean (cfu/100 mL)
East Fork Locust Creek (610)	2006	10	22	816	162
	2007	10	22	4,840	411

Table A-3. Available *E. coli* data for recreational season for the Grand River watershed impaired stream segments.

Waterbody (WBID)	Site Name	Site Code	Organization Code²⁶	Sample Date	Sample Value (cfu/100mL)
Grand River (593)	Grand River at Sumner	593/36.0	USGS	10/21/1997	1,100
				4/22/1998	310
				5/19/1998	15
				7/21/1998	36
				8/18/1998	25
				9/3/1998	5,400
				10/28/1998	270
				4/13/1999	300
				5/19/1999	2,700
				6/15/1999	3,000
				7/27/1999	30
				8/10/1999	7
				9/13/1999	35
				10/26/1999	17
				5/2/2000	20
				6/12/2000	90
				7/11/2000	300
				8/2/2000	60
				9/12/2000	75
				10/2/2000	12
				4/17/2001	3,600
				5/1/2001	40
				6/19/2001	6,400
				7/10/2001	250
				8/13/2001	16
				9/5/2001	44
				10/17/2001	17,000
				4/10/2002	4,000
				5/7/2002	11,000
				6/10/2002	4
				7/16/2002	31
				8/13/2002	280
				9/4/2002	66
				10/22/2002	30
				4/11/2003	20
				5/2/2003	6,400

²⁶ USGS = United States Geological Survey

7/29/2003	100
8/21/2003	2
9/9/2003	190
10/21/2003	320
4/6/2004	67
5/19/2004	25,000
6/28/2004	250
7/15/2004	5,300
8/16/2004	38
9/2/2004	550
10/12/2004	5,700
4/4/2005	2
5/3/2005	110
6/22/2005	190
7/12/2005	18
8/22/2005	490
9/7/2005	46
10/12/2005	92
4/10/2006	780
5/3/2006	3,900
6/21/2006	66
7/6/2006	29
8/2/2006	36
9/6/2006	190
10/10/2006	27
4/3/2007	3,300
5/2/2007	570
6/6/2007	320
7/10/2007	17
8/14/2007	1,200
9/11/2007	84
10/23/2007	2,200
4/16/2008	500
5/6/2008	640
6/2/2008	1,700
7/9/2008	240
8/4/2008	240
9/2/2008	120
8/17/2009	3,900
4/1/2009	1,500
5/5/2009	920
6/2/2009	500

7/28/2009	54
9/1/2009	1,300
10/15/2009	88
5/26/2010	26,000
6/15/2010	12,000
7/6/2010	22,000
8/3/2010	290
9/14/2010	16,600
10/5/2010	200
4/19/2011	8,400
5/3/2011	110
7/12/2011	80
8/3/2011	64
9/7/2011	24
10/13/2011	28
4/10/2012	310
5/3/2012	9,000
6/5/2012	21
7/18/2012	60
8/6/2012	46
8/6/2012	43
9/5/2012	340
10/3/2012	80
4/1/2013	3,200
5/8/2013	2,400
6/19/2013	320
7/31/2013	52
8/21/2013	10
9/12/2013	37
10/30/2013	30
4/8/2014	64
5/28/2014	320
6/17/2014	180
7/9/2014	7,300
8/12/2014	150
9/8/2014	460
10/7/2014	2,700
4/21/2015	8,800
5/26/2015	4,200
6/23/2015	1.E+11
10/20/2015	25
7/21/2015	3,900

8/18/2015	16,000
9/16/2015	330
4/4/2017	1,600
6/6/2017	30
8/8/2017	26
6/27/2017	48
7/25/2017	184
9/12/2017	72
10/16/2017	110
4/26/2018	28
5/8/2018	2,900
7/9/2018	66
8/7/2018	170
9/19/2018	79
10/16/2018	1,800
5/24/2016	35
4/5/2016	45
6/7/2016	590
7/19/2016	40
8/2/2016	7,200
9/13/2016	630
10/18/2016	64
5/6/2019	550
4/2/2019	2,100
6/4/2019	600
7/23/2019	2,500
8/19/2019	2,600
9/9/2019	3,200
10/8/2019	1,000
7/7/2020	88
8/12/2020	1,400
9/8/2020	120

Table A-4. Available *E. coli* data for recreational season for the East Fork Grand River watershed impaired stream segments.

Waterbody (WBID)	Site Name	Site Code	Organization Code ²⁷	Sample Date	Sample Value (cfu/100mL)
East Fork Grand River (457)	E. Frk. Grand River near Allendale	457/25.0	USGS	5/17/2000	210
				7/12/2000	110
				9/19/2001	930
				5/1/2001	1,700
				5/3/2001	650
				7/12/2001	62
				5/8/2002	800
				7/31/2002	40
				9/4/2002	98
				4/29/2003	490
				5/21/2003	180
				7/16/2003	300
				9/4/2003	130
				5/19/2004	22,000
				7/8/2004	120
MDNR			MDNR	9/9/2004	800
				5/24/2005	900
				7/7/2005	67
				9/15/2005	670
				5/22/2007	98
				10/24/2016	118
				4/17/2017	4,839
				5/11/2017	4,839
				6/8/2017	272
				8/7/2017	313
				8/28/2017	345
				4/1/2019	308
				4/25/2019	131
				5/28/2019	4,839
				6/10/2019	197

²⁷ MDNR = Missouri Department of Natural Resources

Table A-5. Available *E. coli* data for recreational season for the Middle Fork Grand River watershed impaired stream segments.

Waterbody (WBID)	Organization Code	Site Name	Site Code	Sample Date	Sample Value (cfu/100mL)
Middle Fork Grand River (468)	MDNR	M. Frk. Grand R. at Grant City	468/22.6	7/28/2020	4,839
				8/6/2020	173
				8/25/2020	248
				9/15/2020	411
				10/20/2020	228
				5/18/2021	4,839
				6/17/2021	1,553
				6/17/2021	1,733
				7/15/2021	687
				8/26/2021	4,839
				10/21/2021	548
				4/19/2022	61
Middle Fork Grand River (468)	MDNR	M. Frk Grand R. above Hwy. YY	468/16.0	7/28/2020	4,839
				8/6/2020	517
				8/25/2020	91
				9/15/2020	579
				10/20/2020	579
				5/18/2021	4,839
				6/17/2021	291
				7/15/2021	548
				8/26/2021	4,839
				4/19/2022	50
				6/9/2022	4,839
Middle Fork Grand River (468)	MDNR	M. Frk Grand R. above Hwy. 136	468/2.0	7/28/2020	4,839
				8/6/2020	104
				8/25/2020	68
				9/15/2020	115
				10/20/2020	185
				5/18/2021	4,839
				7/15/2021	2,420
				8/26/2021	687
				10/21/2021	214
				4/19/2022	17
				6/9/2022	4,839
Middle Fork Grand River (468)		M. Frk. Grand R. below Hwy 169	468/9.4	7/28/2020	4,839
				8/6/2020	161

			8/6/2020	125
			8/25/2020	260
			9/15/2020	108
			10/20/2020	161
			5/18/2021	4,839
			6/17/2021	4,839
			7/15/2021	4,839
			8/26/2021	365
			10/21/2021	272
			4/19/2022	28
			6/9/2022	4,839
USGS	M. Frk. Grand R. near Grant City	468/20.0	5/17/2000	570
			7/12/2000	3
			9/7/2000	27
			5/1/2001	32,000
			7/12/2001	140
			9/19/2001	1,100
			5/8/2002	6,100
			7/31/2002	300
			9/4/2002	480
			5/21/2003	1,000
			7/16/2003	120
			9/3/2003	1,000
			5/19/2004	68,000
			7/8/2004	1,200
			9/9/2004	110
			5/24/2005	770
			7/7/2005	420
			9/15/2005	140
			5/24/2006	730
			7/26/2006	290
			9/7/2006	800
			4/5/2007	400
			5/24/2007	590
			6/21/2007	270
			7/26/2007	330
			9/20/2007	770
			5/30/2008	39,000
			9/18/2008	1,100
			5/8/2009	400
			7/15/2009	1,600
			9/4/2009	510

10/23/2009	2,400,000
5/5/2010	270
7/16/2010	540
9/14/2010	15,000
10/22/2010	134
5/26/2011	23,000
7/19/2011	420
9/27/2011	460
10/18/2011	310
5/3/2012	18,000
9/19/2012	130
10/16/2012	240
5/8/2013	1,060
7/16/2013	72
9/24/2013	160
10/22/2013	350
5/19/2014	190
7/8/2014	24,000
9/3/2014	540
10/21/2014	640
5/5/2015	66,000
7/7/2015	26,000
9/15/2015	310
10/27/2015	170
5/4/2016	1,400
7/7/2016	34,000
9/13/2016	28,000
10/4/2016	120
5/10/2017	790
7/19/2017	1,200
9/20/2017	1,300
10/18/2017	2,100
5/9/2018	760
7/10/2018	580
9/6/2018	86,000
10/3/2018	640
4/3/2019	240
5/8/2019	38,000
7/17/2019	160
9/5/2019	95
10/2/2019	124,000
6/2/2020	1,100

			7/15/2020	14,000
			9/16/2020	200
			10/14/2020	80

Table A-6. Available *E. coli* data for recreational season for the Locust Creek watershed impaired stream segments.

Waterbody (WBID)	Organization Code	Site Name	Site Code	Sample Date	Sample Value (cfu/100mL)
Locust Creek (606)	USGS	Locust Cr. at Calico Rd.	606/20.6	9/19/2013	110
				7/25/2018	150
				8/22/2018	520
	MDNR	Locust Cr. 3 mi. South of Browning	606/28.4	7/11/2007	50
				7/26/2007	48
				8/7/2007	135
				8/12/2021	62
	MDNR	Locust Cr. at Locust Cr. Ave.	606/3.8	8/25/2021	62
				9/9/2021	19
				10/14/2021	345
				4/21/2022	24
				6/16/2022	435
				9/1/2006	179
				9/6/2006	1,990
				9/13/2006	68
	MDNR	Locust Cr. at Hwy. MM	606/31.2	9/20/2006	53
				9/27/2006	38
				7/11/2007	66
				7/24/2007	45
				7/26/2007	37
				8/1/2007	27
				8/7/2007	56
				9/1/2006	249
				9/6/2006	410
				9/13/2006	36
	MDNR	Locust Cr. at Rocky Ford Access	606/33.3	9/20/2006	25
				9/27/2006	19
				7/11/2007	6
				7/24/2007	10
				7/26/2007	5
				8/1/2007	11
				8/7/2007	17

			8/12/2021	79
			8/25/2021	59
			9/9/2021	93
			9/21/2021	197
			10/14/2021	214
			4/21/2022	1,120
			6/16/2022	308
			10/25/1999	360
			4/19/2000	340
			5/11/2000	100
			6/15/2000	3,200
			7/27/2000	40
			9/19/2000	140
			10/25/2000	240
			4/25/2001	250
			5/23/2001	350
			6/18/2001	540
			6/27/2001	190
			7/24/2001	850
			8/7/2001	620
			9/11/2001	67
			10/24/2001	21,000
			4/16/2002	210
			5/22/2002	140
			6/27/2002	390
			7/25/2002	240
			8/20/2002	2,700
			9/9/2002	250
			10/16/2002	60
			4/24/2003	320
			5/7/2003	1,600
			6/10/2003	47,000
			7/11/2003	2,100
			9/16/2003	160
			10/21/2003	100
			4/21/2004	2,200
			5/12/2004	460
			6/24/2004	370
			7/15/2004	8
			9/15/2004	440
			10/28/2004	3,800

4/6/2005	230
5/10/2005	82
6/28/2005	44,000
7/13/2005	220
8/18/2005	590
9/19/2005	230
10/4/2005	360
4/12/2006	75
5/11/2006	220
6/13/2006	210
7/18/2006	1,700
8/8/2006	1,000
9/19/2006	1,900
10/24/2006	420
4/26/2007	46,000
5/9/2007	3,400
6/26/2007	940
7/17/2007	150
8/22/2007	6,800
9/26/2007	360
10/17/2007	900
4/17/2008	280
5/20/2008	130
6/19/2008	3,000
7/17/2008	630
8/14/2008	14,000
9/25/2008	1,100
8/18/2010	500
4/23/2009	230
5/14/2009	6,600
6/25/2009	4,700
7/23/2009	310
8/19/2009	2,300
9/17/2009	140
10/7/2009	1,120
4/22/2010	160
5/21/2010	23,000
6/16/2010	3,500
7/29/2010	230
9/23/2010	7,000
10/6/2010	360

4/7/2011	270
5/5/2011	660
6/9/2011	2,000
7/13/2011	1,500
8/17/2011	2,600
9/15/2011	200
10/5/2011	58
4/18/2012	530
5/22/2012	52
6/6/2012	230
8/7/2012	210
9/12/2012	200
7/24/2012	77
10/2/2012	3,200
4/8/2013	2,200
5/22/2013	2,300
6/25/2013	3,900
7/9/2013	190
8/13/2013	15,000
4/8/2014	54
5/7/2014	110
6/10/2014	1,400
7/16/2014	860
8/19/2014	3,700
9/23/2014	260
10/7/2014	700
4/15/2015	100
5/12/2015	1,100
6/16/2015	1,400
7/29/2015	66,000
8/11/2015	1,200
9/2/2015	1,500
10/6/2015	470
4/12/2017	550
5/17/2017	1,400
6/7/2017	300
7/12/2017	1,500
8/9/2017	240
9/27/2017	480
10/4/2017	120
4/11/2018	24

			5/16/2018	320
			6/5/2018	970
			9/19/2018	6,800
			10/23/2018	160
			4/5/2016	80
			5/18/2016	860
			6/22/2016	2,400
			7/20/2016	1,300
			8/24/2016	970
			9/21/2016	480
			10/18/2016	84
			4/9/2019	60
			6/5/2019	300
			7/10/2019	260
			7/23/2019	2,000
			8/14/2019	230
			9/18/2019	510
			10/23/2019	150
			6/9/2020	3,400
			6/24/2020	3,300
			7/22/2020	2,200
			9/1/2020	540
			9/30/2020	90
			10/21/2020	77
MDNR	Locust Creek at 205th St	606/81.5	4/21/2022	4,839
			6/16/2022	4,839
	Locust Cr. above 205th St.	606/81.8	8/12/2021	1,553
			8/25/2021	4,839
			9/9/2021	344
			9/21/2021	4,839
			10/14/2021	1,300

Table A-7. Available *E. coli* data for recreational season for the East Fork Locust Creek watershed impaired stream segments.

Waterbody (WBID)	Organization Code	Site Name	Site Code	Sample Date	Sample Value (cfu/100mL)
East Fork Locust Creek (608,610)	MDNR	E. Frk. Locust 0.1 mi.below Milan lagoon	608/15.7	7/11/2007	1,120
				7/24/2007	4,840
				7/26/2007	222
				8/1/2007	816
				8/7/2007	1,730
		E. Frk. Locust Cr. 2.5 mi. below Milan lagoon	608/13.1	9/1/2006	649
				9/6/2006	686
				9/13/2006	579
				9/20/2006	365
				9/27/2006	1,986
				7/11/2007	1,300
				7/24/2007	2,420
				7/26/2007	980
				8/1/2007	1,200
				8/7/2007	1,200
				8/27/2018	71
				9/17/2018	4,839
				10/1/2018	4,839
				10/15/2018	4,839
E. Frk. Locust Cr. at Hwy C		E. Frk. Locust Cr. at Hwy C	608/16.0	10/29/2018	4,839
				7/24/2019	4,839
				9/11/2019	4,839
				9/25/2019	4,839
				10/28/2019	4,839
				7/23/2020	4,839
				8/12/2020	4,839
				9/1/2020	4,839
				9/22/2020	4,839
				9/22/2020	4,839
				10/8/2020	4,839

			8/22/2019	4,839
			7/24/2019	4,839
			9/11/2019	921
			9/25/2019	4,839
			10/28/2019	345
			7/23/2020	1,986
			8/12/2020	1,300
			9/1/2020	4,839
			9/22/2020	727
			9/22/2020	461
			10/8/2020	548
			9/1/2006	308
			9/6/2006	133
			9/13/2006	178
			9/20/2006	59
			9/27/2006	22
			7/11/2007	4,840
			7/24/2007	613
			7/26/2007	214
		610/7.3	8/1/2007	22
			8/7/2007	206
			8/12/2021	172
			8/25/2021	127
			9/9/2021	727
			9/21/2021	816
			10/14/2021	57
			4/21/2022	1,986
			6/16/2022	866
			9/1/2006	365
			9/6/2006	74
		610/0.7	9/13/2006	816
			9/20/2006	127
			9/27/2006	461
			8/1/2007	1,200
			7/11/2007	597
			7/24/2007	291
		610/0.3	7/26/2007	148
			8/7/2007	1,550
			8/12/2021	2,420
			8/25/2021	1,986
			9/9/2021	4,839

			9/21/2021	1,011
			10/14/2021	727
			4/21/2022	1,733
			6/16/2022	2,420

Appendix B

Development of *E. coli* Load Duration Curves

Overview

Load duration curves were used to develop the *E. coli* TMDLs for the impaired stream segments in the Grand River watershed. Load duration curves visually display the loading capacity of a water body at all possible flows based on historical flow data and the defined target concentration for each pollutant. For these TMDLs, a portion of the *E. coli* loading capacity is assigned as a wasteload allocation based on the individual design flows of domestic wastewater treatment facilities present in the watershed. Ten percent of the loading capacity is reserved as an explicit margin of safety. For some waters, at certain extreme low flow that are frequently exceeded (e.g., 99th percentile exceedance) only implicit margins of safety are applicable.

Methodology

Load duration curves are based on flow duration curves developed using a long-term time series of daily flows and a numeric water quality target. Average daily flow data that are representative of the impaired segment are used to develop the flow duration curve. If sufficient flow records for the impaired stream segment are not available, then flow data collected from a gage in a representative watershed may be used, or a flow duration curve can be derived by synthesizing long-term flow data from several gages within the same ecological drainage unit.

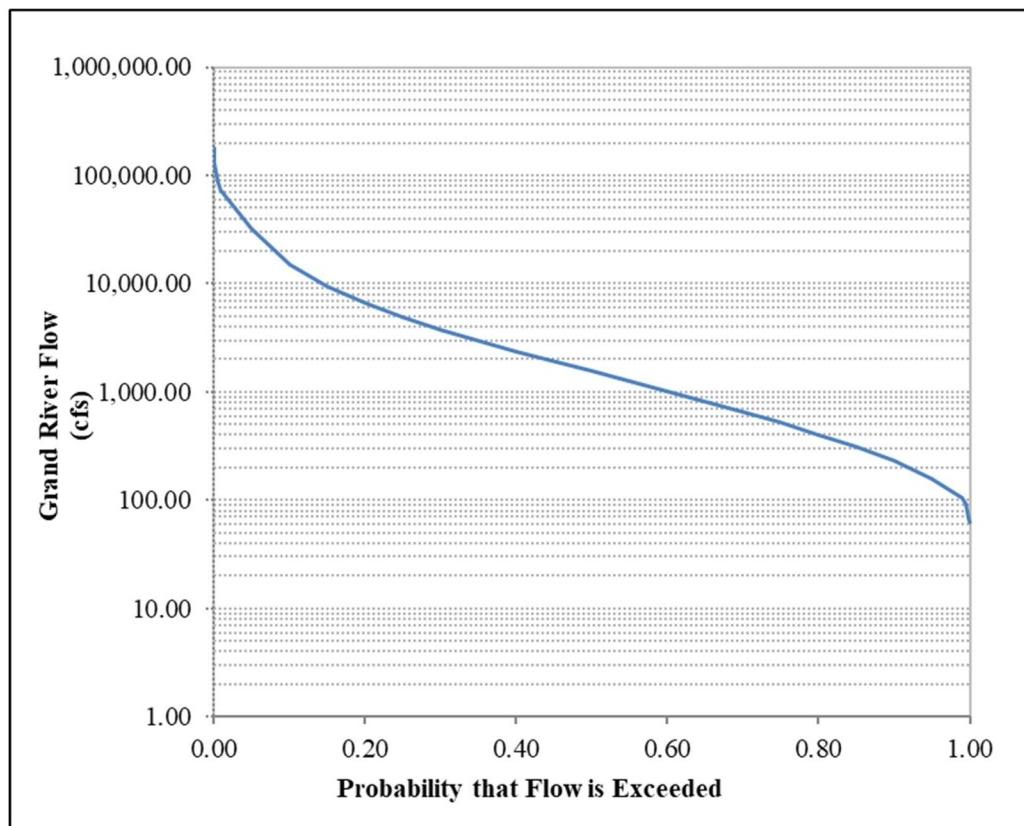
For the Grand River, flow estimates were area-corrected based on flows measured at USGS stream gage 06902000, located on Grand River near Sumner, Missouri from January 1990 to October 2022. For the Middle Fork Grand River, the Middle Fork Grand River, Locust Creek, and East Fork Locust Creek, flow estimates were area corrected based on flows measured at USGS stream gage 06896400, located on East Fork Grand River near Albany, Missouri from June 2007 to October 2022. Average daily flows were corrected based on the proportion of the area draining to the impaired water body segment. In addition to calculating the total daily flow of the impaired segment, the daily flow was calculated for each state using correction factors based on the proportion of the drainage area for Missouri and Iowa (Table B-1). Figure B-1 presents the flow duration curve developed for the impaired segment.

Because the Middle Fork Grand River, East Fork Grand River, and Locust Creek watersheds are located within two states, the loading capacities were derived with considerations to both Missouri and Iowa water quality standards. For this TMDL, the loading capacity for each stream is based on 126 cfu/100mL, average daily flows, and a conversion factor of 24,465,715 in order to generate the loading capacity in units of cfu/day. The total loading capacities for these streams is the sum of allowable loading in Missouri and Iowa.

Table B-1. Information used for developing area corrected flow records²⁸

Watershed	Grand River ¹	East Fork Grand River ²	Middle Fork Grand River ²	Locust Creek ²	East Fork Locust Creek ²
Watershed Area (mi²)	7,890	433	198	223	124
Gage Watershed Area (mi²)	6,880	401	401	401	401
Gage Ratio	1.15	1.08	0.49	0.56	0.31
Watershed to Gage Percentage	113.89%	107.98%	49.38%	55.61%	30.92%
Iowa Watershed Area (mi²)	1,734	166	58	49	N/A
Iowa Watershed Ratio	0.22	0.38	0.29	0.22	N/A

¹Applied gage = USGS 06902000 Grand River near Sumner, MO
²Applied gage = USGS 06896400 East Fork Grand River at Albany, MO

**Figure B-1. Grand River Flow Duration Curve**²⁸ Flow data that were in provisional status at the time of this report were not used.

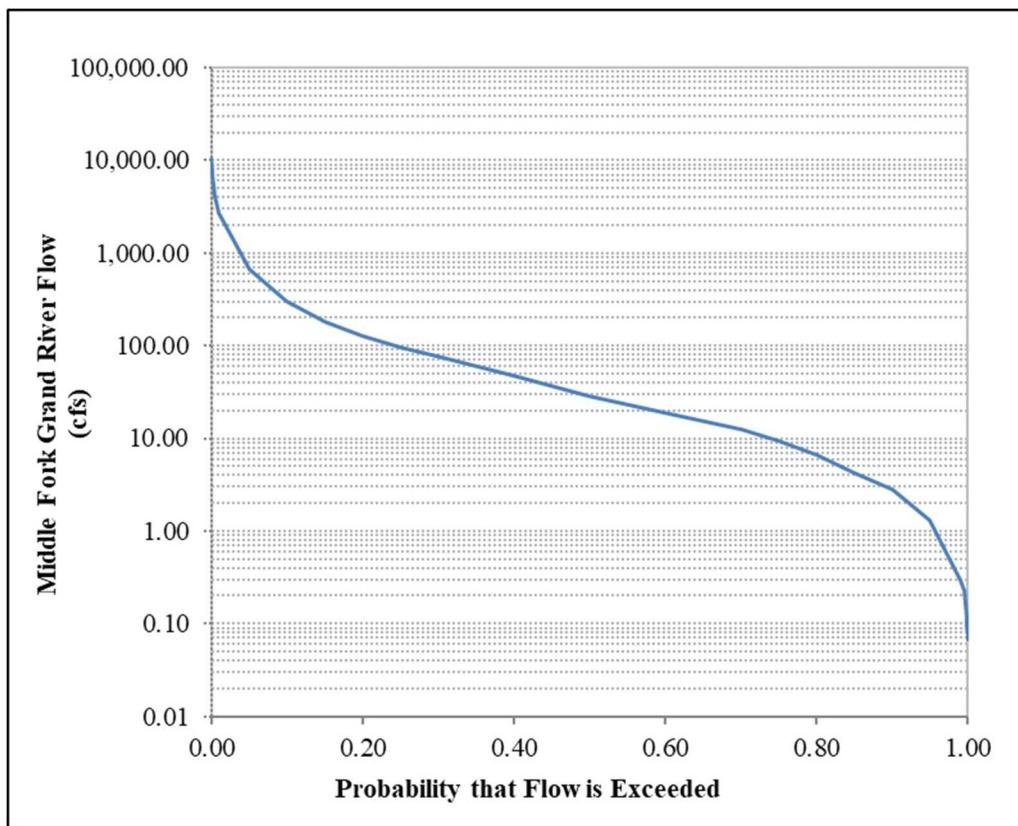


Figure B-2 Middle Fork Grand River Flow Duration Curve

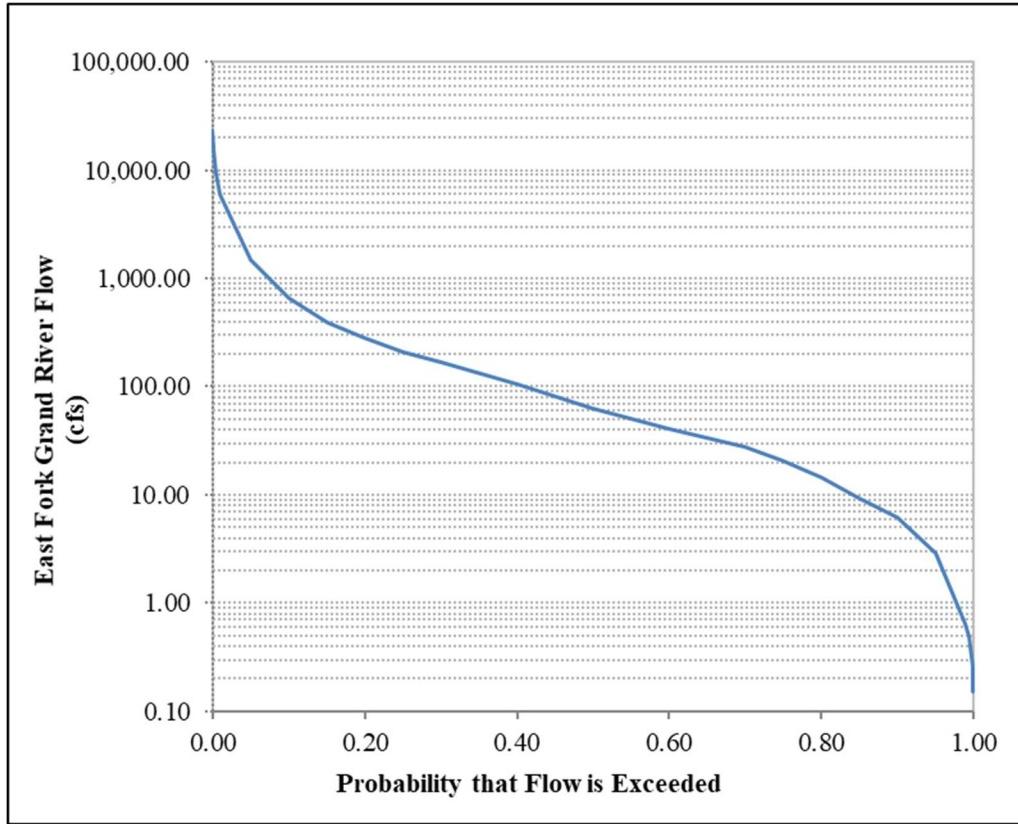


Figure B-3 East Fork Grand River Flow Duration Curve

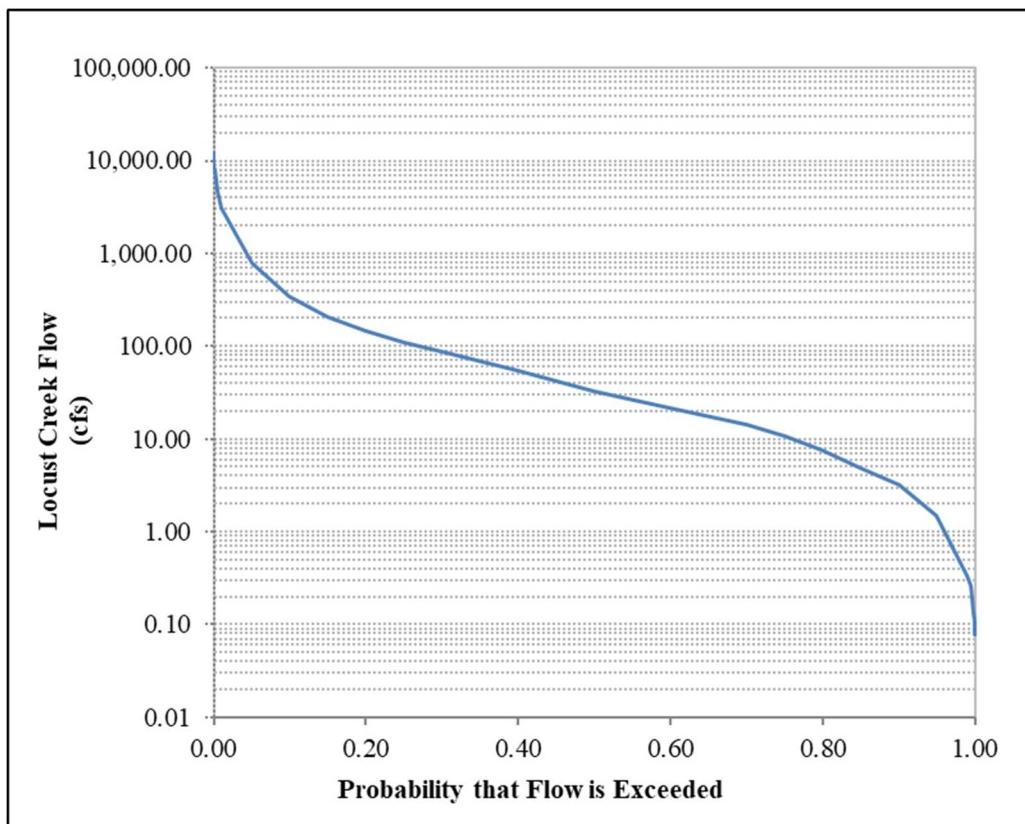


Figure B-4 Locust Creek Flow Duration Curve

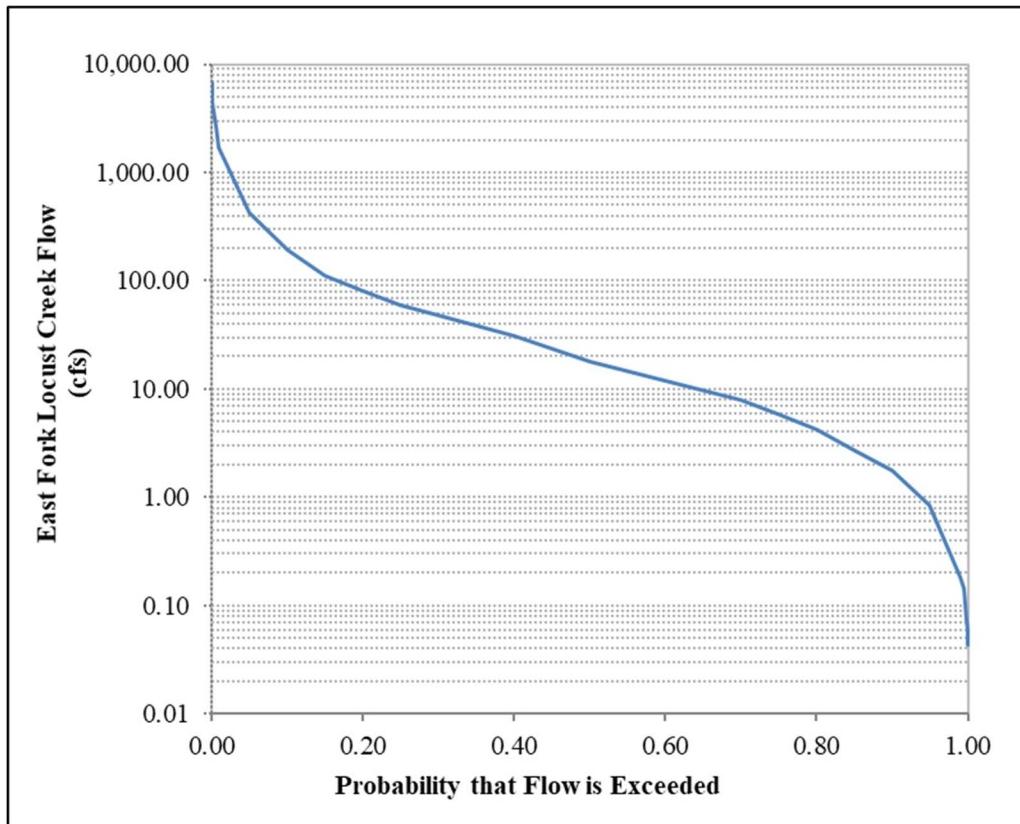


Figure B-5 East Fork Locust Creek Flow Duration Curve